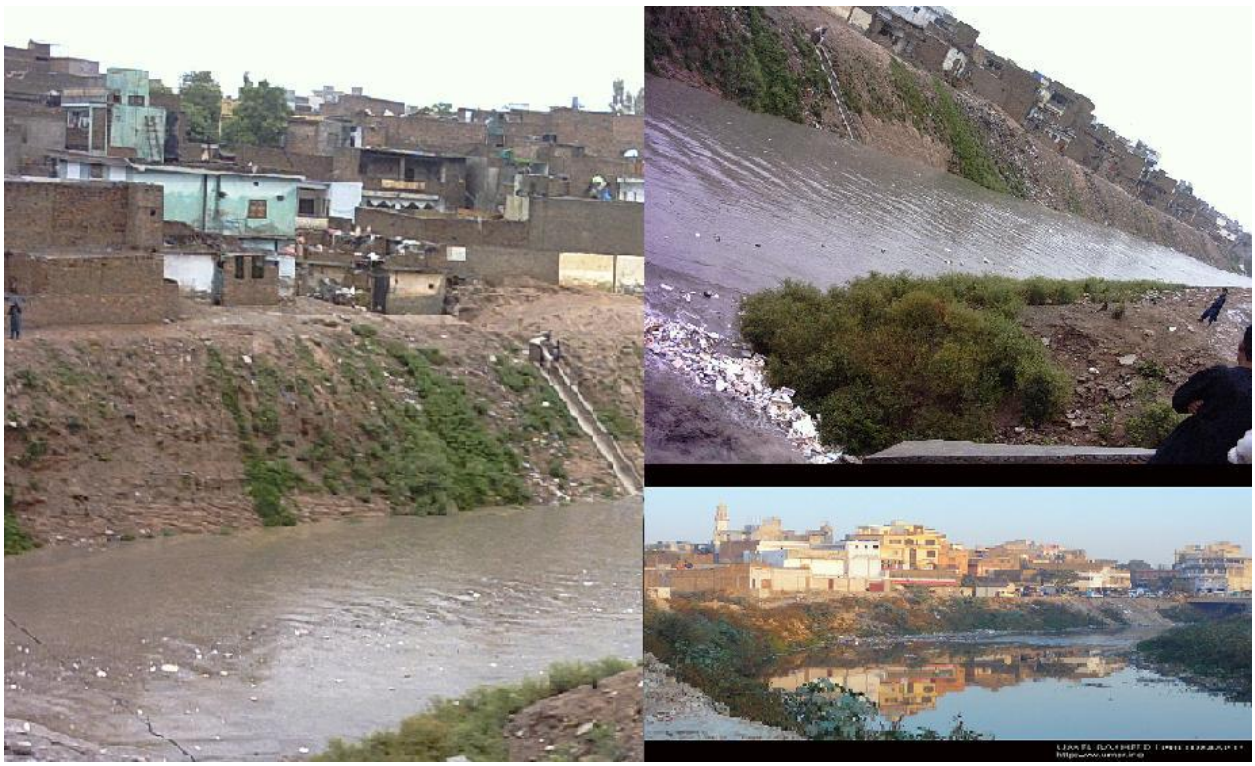
Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development



Making Better Choices by using IWRM, Lai Nullah A case study of Pakistan

Babar Khan

Uppsala 2010
EX0658 Master Thesis 30hp
Swedish University of Agricultural Sciences

Making Better Choices by using IWRM, Lai Nullah A case study of Pakistan

Babar Khan

Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences

Department of Urban and Rural Development

Key Words: Droughts, Water Security, Lai Nullah, IWRM,

Dredging, Pakistan, Rain water harvesting

Thesis No

EX0658 Master Thesis in Integrated Water Resource Management, 30 hp, Master E, Uppsala, 2010

Source of pictures on the front cover: Google

Supervisor: Sriskandarajah, Department of Urban and Rural Development, Swedish University of Agricultural Sciences, Sweden

Examiner: Ashok Swain, Professor of Peace and Conflict Research, Uppsala University; Director, Uppsala Center for Sustainable Development, Sweden

E-mail:

Bakh0002@stud.slu.com

http:/ epsilon.slu.se

Abstract

This thesis is an effort to find a relationship between floods and droughts in context of climate change and exploring the options and practices that addresses both these issues in an integrated way leading to better, sustainable and reliable solutions. The study defines the integrated methodology for understanding relationships between different issues of interest and can be applied at any scale from local to national. Lai Nullah is located in an urban centre of Rawalpindi, Pakistan that experience regular floods and water scarcity issues as a result of too much water during the monsoon rains and too less water during the dry periods. Different conventional options and strategies have been used during different projects to tackle both the issues. The study gives a detail analysis of importance to using structural and non structural measures together while planning or project design. As a part of best practice, case studies have been included to measure and understand the effectiveness of different options used in Lai Nullah case. Research found that rain water should be taken as an opportunity rather than threat in context of climate change and two options has been explained that deals with rain water harvesting in way that not only mitigates the flood impact but also recharge the ground water.

Key Words: *Droughts, Water Security, Lai Nullah, IWRM, Dredging, Pakistan, Rain water harvesting*

Acknowledgement

My sincere gratitude and appreciation goes to my supervisors Mr. Sriskandarajah, Department of Urban and Rural Development, Swedish University of Agricultural Sciences, Sweden who have been very patient and helpful throughout and Helen Arvidsson Educational Adm.,SOL,teknik/administration who was always there throughout the program, All my colleagues fellow in the program specially Ammad for sending me the relevant documents for thesis.

Last but not least prayers and love of my family without which it would have never been possible

Abbreviations and Acronyms

ADB	Asian Development Bank
ASR	Aquifer Storage and Recovery
CCI	Council of Common Interest
CRS	Catholic Relief Services
CSIRO	Commonwealth Scientific and Industrial Research Organization
CDG	City District Government
CRED	Centre for Research on the Epidemiology of Disasters
EDO	Executive District Officer
FFC	Federal Flood Commission
FFD	Flood Forecast Division
FFWS	Project flood forecast and warning system
FFP	Fit-for-purpose principle
FRU	Flood Reconstruction Unit
Ft	Feet
GCMs	projects
GDP	Grass Domestic Product
GWP	Global Water Partnership
GON	Government of the Netherlands
GL	Gallen
GL/a	Gigalitres a year
IPCC	Intergovernmental Panel on Climate Change
IFM	Integrated Flood Management
IWRM	Integrated Water Resource Management
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JCC	Joint Coordination Committee
Maf	Million Acre Foot
MGD	Million Gallon per Day
NDMA	National Disaster Management Authority
NODMC	National Oversight Disaster Management Council

NCAR	National Centre for atmospheric Research
OFDA	Office of U.S. Foreign Disaster Assistance
PCIWI	Pakistan Commission for Indus Water
PIDAs/PIDs,	Provincial Irrigation and Drainage authorities
PMD	Pakistan Meteorological Department
PMPIU	Project Management and Policy Implementation Unit
PWP	Pakistan Water Partnership
PTFCC	Pakistan Task Force on Climate Change
REIP	Rawalpindi Environmental Improvement Project
RDA	Rawalpindi Development Authority
RWASA	Rawalpindi Water and Sanitation Authority
RDF	Refuse derived fuel
RCB	Rawalpindi Cantonment Board
SWOT	Strength, Weakness, Opportunity, threat Analysis
TA	Technical assistance
TMA	Tehsil Municipal Administration
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations secretariat of the International Strategy for Disaster Reduction
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization
WCD	World Commission on Dams
WSSD	World Summit on Sustainable Development
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Authority
WTP	Willing to pay
MWP	Ministry of Water & Power
WUA	Water Users Association
WSUD	Water sensitive urban design

Table of Contents

1. INTRODUCTION

Today where the world has witnessed a great progress in science and technology along with all the sectors that has paved more ways for development and brought more opportunities, there is an increasing fear due to increasing natural catastrophes, population growth, pollution and global warming. The IPCC Summary for Policymakers (2007) says "*Global warming is likely to lead to greater extremes of drying and heavy rainfall and increase the risk of droughts and floods that occur in many different regions*." World health Organization also on the other hand stated in their report that there has been increase in number of deaths and effected people due to weather disasters such as floods and droughts (WHO,1999). Floods and droughts are the extreme events that is dependent on the hydrological cycle and water distribution pattern among different regions with variable rate and intensity leaving some places dry and some wet but technology and human intervention has made things different by artificially changing and controlling this cycle with modern management options converting deserts into agricultural land to meet the demands of increasing population. Varying and unexpected weather patterns has grabbed the attentions of researchers and policymakers towards water security options for water management that are cost efficient, reliable and non threatening.

Pakistan is an agricultural based country that contributes 22% (2005) in country's GDP and employed 45% of the labor force (Beintema et al, 2007) showing the importance of water for state development and survival. Along with extreme floods and droughts over extraction of ground water, pollution, increasing population, climate change is the major challenges for the state. Floods and Droughts are the events that Pakistan has been facing since when it was founded in 1947 and a huge cost it has been paying until now with human and economic losses .For to address this major issue structural and non structural initiatives were taken at different level to mitigate the flood and drought impact. With the rapid population growth, and vulnerable government who has been throughout a victim to dictatorship, extremism, terrorism and corruption, sustainable policies has been hard through out to implement.

1.1 Floods

Floods generally can be described as an extreme water runoff situation as a result of which human lives, property and infrastructure is threatened (Estrela et al, 2001). Extreme weather

events with a resulting massive water flow can cause severe damages to population and property especially where it interferes with human land use activities. According to Red Cross report for the period (1971-1995) 12 700 humans lost their lives effecting 60 million and leaving 3.2 million homeless in an average year (Berz, 2001).Based on the data in nine years 1990-1998 it was higher than three and half decades 1950-1985 (Kundzewicz, 2002). Since 1990 there have been some 30 floods worldwide in each of which the material losses exceeded one billion US dollar or the number of fatalities were greater than one thousand or both (Kundzewicz 2003).

1.1.1 Floods in Pakistan:

Intergovernmental Panel on Climate Change studies indicating that because of climate change, the mega-dalta region in South Asia is at increasing risk of flooding along with increased frequency and intensity of winds and rainfall (Christensen et al, 2007).Summer 2010 floods are one of the worst floods in Pakistan since last 80 years (New York Times, 2010).

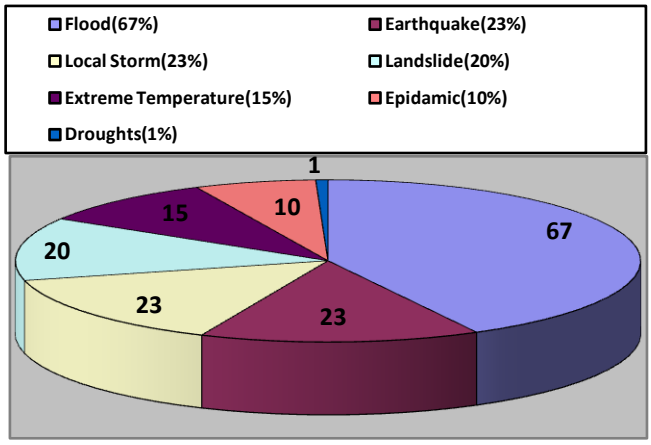


Figure 1 (Source Reliefweb 2010)

There had been number of natural disasters in Pakistan but the most frequent ones destroying the economy and taking thousands of innocent lives were Floods. According to OFDA/CRED database floods has been extremely dominant over all other natural disasters in Pakistan with 67% followed by Earthquakes and local storms that are 23%. Dr Qamar who is also the lead author of Pakistan's first Draft National Climate Change Policy states that, country is heading for increased frequency and intensity of extreme weather events that includes frequent floods and droughts (Government of Pakistan Ministry of Environment, 2011).

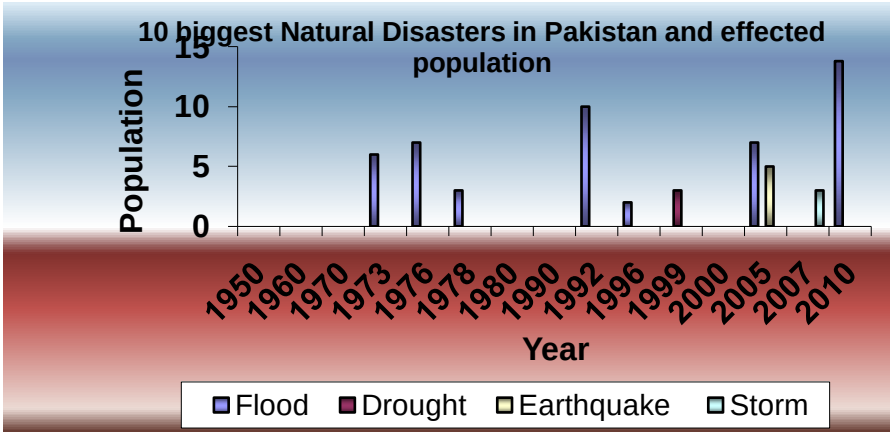


Figure 2 (Source Reliefweb 2010)

Figure1, 2 Reliefweb (2010) giving a clear view of all the natural disasters in Pakistan since 1900. This figure clearly shows how much it is important for Pakistan to devise plans and strategies not only for flood mitigation but conserve the precious fresh water resource to get waste as "Pakistan is an agricultural based country and two third of the population is directly or indirectly dependent on agriculture for livelihood" (Ali,2000). Recent series of 2010 floods in Pakistan were one of the worst of all those 12 floods from 1947 to 1995.It began in the north part of Pakistan and in late July and spread in august along the Indus basin causing wide spread displacement and loss of resources. 1677 people died as of early September as a result of floods and damage to houses, crops, irrigation and other infrastructure that has been estimated 1.5 billion or more. 17.6 million People have been affected by these floods is almost the double of the number to the floods in 1992(IEG, 2010:03).

1.1.2 Flood Management institutions in Pakistan

It's not the first time Pakistan has been hit by flood or disaster. Dozens of institutions and permanent departments have been formed over the period of time to mitigate and manage the disasters. Pakistan has a number of institutions responsible for flood control and management at different level. After independence in 1947 a central Engineering authority (IUCN, n.d.) was formed to deal with power, water and allied engineering issues at national level. It was also responsible to projects execution at different levels. WAPDA (Water and Power Development Authority) was created in 1959, with reduced tasks at federal level and central engineering authority was re designated as Chief Engineering Advisor's office with redefined role.

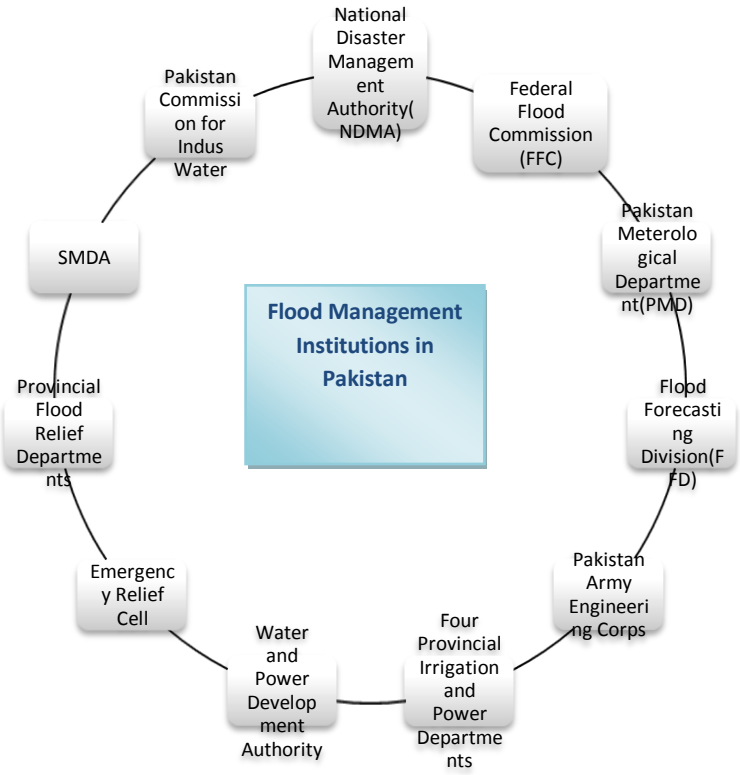


Fig.3 Source (IUCN n.d)

Until 1976 provincial governments were totally taking the responsibility of flood control, planning and project execution. It was later on the need felt after the disastrous floods of 1973 and 1976 and its damages to form another institution. In January 1977 Federal Flood Commission was established which is the principal institution for flood planning and control in Pakistan. Its mandate includes approval of flood control schemes, National Flood protection Plan, review of flood damages, plans for construct works, improvement in flood forecasting and warning system, monitoring and evaluation.

Apart from that the institutions playing vital role in flood management are PIDAs/PIDs, WAPDA, Provincial relief organizations, Pakistan Army, Pakistan Commissioner for Indus water, Emergency relief cells and National Flood Forecasting Division.

According to Planning commission (2011) After 2010 floods despite the existence of dozens of flood management, control and response institutions planning commission of Pakistan created some more institutions with disbursement of lot of budget worth 292,191.26 million Rupees with a list of 245 projects.

- Council of Common Interest (CCI)

- National Oversight Disaster Management Council (NODMC)
- Flood Reconstruction Unit (FRU)

1.1.3 Causes of Floods in Pakistan:

Climate change and monsoon are mainly held responsible for floods in Pakistan and other major factors are almost ignored that includes structural, non structural measures, land use planning, encroachments, deforestation, political power games, garbage and drain blocks causing floods and many more.

1.1.3.1 Climate Change and Floods:

United Nation Framework Convention on Climate Change (1992), in its Article 1, defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

PTCC (2010) projected that"climate change will increase the variability of the monsoon rains and enhance the frequency and severity of extreme events such as floods and droughts". According to this report with the increase and variation in monsoon pattern Pakistan could face more severe floods and droughts. There are mainly two major factors linked with climate change that is mainly responsible for flooding in Pakistan which includes Russian heat wave and El-Nino.

a) Russian Heat Wave:

To some extant unusual 2010 floods in Pakistan by rainfall is connected to Russian heat wave raising more questions on global climate change (Marshall, 2010).

b) Monsoon and El-Nino

According to Pakistan Metrological department Monsoon is defined as the prevailing wind direction that changes by at least 1200 between January & July (Sarfaraz, 2007).Summer rains from July to September are considered as monsoonal and compromise 50 to 70% of Pakistan's annual rainfall (Kazi, 1951 & Kureshy, 1998). Monsoon precipitation increased everywhere

except in coastal regions and the Western Balochistan Plateau during 1951-2000(Mulk & Ahmad, 2010:29).

Study was made by Abdul Rashid to see a relationship between El-Nino and Monsoon rainfall in Pakistan and found a negative effect on summer monsoon (Jul – Sept) rainfall of Pakistan (Rashid, 2004).

El-Nino has been defined as worm currents of water that appears annually during the Christmas time along the cost of Ecuador and Peru and lasting only a few weeks to a month or more. Study showed that El-Nino year if there is warming in August, May, July are even it is normal and it is likely to continue or increase in July, August, September then there is likely hood that monsoon rainfall over Pakistan will be in deficit (Rashid, 2004).

1.1.3.2 Deforestation:

Where Extensive deforestation in Pakistan is a threat to environment, ecosystem and wild life is also reduces the water retention capacity that can increase surface runoff, soil erosion, velocity and sediment load of head waters entering the river system (Oxley, 2011:455).

1.1.3.3 Trans-boundary water:

Pakistan had always fear of water that comes from Kashmir to Pakistan via India who had now built many reservoirs and structures and can control the water According to Daily Pakistan one of the renowned newspaper relates “one of the reasons for 2010 floods was a release of big amount of water at Jammu tavi place in River Chenab by India which as a result caused flooding in river Chenab wiping out many villages” (Daily Pakistan, 2010).

1.1.3.4 Breaches:

According to a report by congressional research services the runoff water caused Indus River and its tributaries to breach levees and overflow within urban and rural population. Local people made breaches and breaks in an attempt to protect urban centers (Kronstadt et al, 2010)

1.1.3.5 Poor Governance and Power misuse:

Poor Governance and Water management is a problem that the poor people have to pay the price by losing their innocent lives. Apart from poor governance misuse of political power by the ruling party members and powerful feudal to divert the flood water that could harm their land towards the population is one of the reasons that caused man made flood. Federal minister for sports Ejaz Jakharani from ruling people's party has been accused for illegal flood water diversion to Jaffarabad and Nasirabad districts in Balochistan by setting breaches at jamali bypass. Along with him Federal minister Khursheed shah and Sindh chief minister qaim ali shah were also accused for misusing their power to protect their own lands and diverting water to population that took several innocent lives (Ahmad, 2011).

It is also understandable because governance in Pakistan has never given a good chance to groom and has always been a victim of dictatorships, Marshal Laws, militancy and extremism. "A special report by United States Institute for peace gave their insight about the water a problem In Pakistan resulted from poor water management and mentioned as management failure is concerned both materially and politically is a direct hit on poor governance and engineering mechanism"(Mustafa, 2010:03). The Chairman of Global Network of Civil Society Organizations for Disaster Reduction mentioned in its report that "many organizations along with United Nations have highlighted the Pakistani States Poor emergency response and inadequacy" (Oxley, 2011:456).

1.2 DROUGHTS:

According to background paper on Drought one third of the world's population is living within the area that is exposed to water shortage and 1.1 billon people are lacking access to safe and clean drinking water. This report also reveals that globally droughts are the second most hazardous natural calamities' after floods covering 7.5 % and 11% of the total of global land. The total losses due to droughts affected an area of 970 million Km2 with population of 57.3 billion and GDP value of US$108.6 billion. The scientist's at (NCAR) National Centre for atmospheric Research revealed that from 1970s to early 2000 the percentage of droughts has almost been doubled (Liu, 2007).

Drought has been defined in multiple ways based on the scope and context of study. United Nations secretariat of the International Strategy for Disaster Reduction defines "drought disaster has been defined as a deficiency of precipitation over an extended period of time one or more seasons that result in water shortage. Droughts could also be explained within the wide context of meteorology, hydrology, sociology, agricultural and economics"(UNISDR, 2009).

1.2.1 Droughts in Pakistan

Pakistan has been always having problems with very little water during the dry period and too much water during the wet period. "Droughts are normally described in terms of runoff or precipitation during a certain period of time or interims of reserves available with the obvious limitation of all these interpretations" (Estrela, 2001:12).

Pakistan meteorological department in its reports links drought as also a major and serious concern of the country that has brought extensive damage within all the provinces where average rainfall recorded as low as 200-250mm. Severe drought period for Pakistan was 2000 and 2002 that has effected livelihoods, causalities, caused migration and killed large number of cattle's .As a result of these droughts there were 120 deaths and as a whole 2,200,000 people got affected directly or indirectly. The main arid rangelands in Pakistan are Thar, D G Khan, Cholistan, Western Balochistan, Tharparkar and Kohistan and are within the range of monsoon rainfall so 2 to 3 years within every ten years these areas experience droughts. During 2000 to 2003 droughts phenomenon was pronounced when it spread across 68 districts within all four provinces. (Khan & Khan, 2006:16-18)

1.2.2Causes of Droughts in Pakistan:

One of the main reasons during 1997 was that El-Nino pushed a high pressure over most of India including Pakistan that stopped the passage of monsoon rains causing droughts in Pakistan. El-Nino is a Spanish word means boy and cause extreme weather worldwide (Floods, droughts). It cause droughts in Pakistan, India and Bangladesh and has a deep influence on Indian Monsoon (Khan & Khan, 2006).

1.3 WATER SECURITY:

Policy makers and Researchers in this century has been discussing and writing about food and water security more than ever after unusual climatic extreme variations leading to massive floods and droughts around the globe. "Water security is a sustainable use and protection of water resources and systems and the protection against water related hazards (floods and droughts), safeguarding the water functions in a sustainable way to provide the service for humans without the damaging cost of environment" (Schultz, 2007:02).Many people mix water security with water conservation. The above definition of water security clears this misunderstanding explaining water conservation as a component of water security with conditions.

1.3.1 Water Security& Losses in Pakistan

To cope up with the water and related needs Pakistan has been building small and large dams to meet the water and energy needs of the country and started lining the irrigation channels along with introduction of drip and sprinkle irrigation system to reduce the water losses. On the other hand many awareness programs for water conservation at domestic level have been started by government and non government organizations. Pakistan was once a water rich country and now due to increasing population and lack of reservoirs and depleted ground water state has a major challenge to meet the water demand for domestic, agricultural and industrial sector. In a National Seminar on "Water Conservation, Present Situation and Future Strategy" Dr Shahid Ahmad the second Speaker mentioned that in fifties Pakistan was a water abundant country whose per capita water availability was more than5000 M^3 persons, unfortunately will be a water scarce country by 2017. At present the per capita water availability is (1100 M^3) persons, will be reduced to (1000 M/³) by 2017 unless an effective measure is taken to conserve a huge amount of water loss (PMPIU, 2009).

Per capita Water Availability in Pakistan

Year	**Population(million)**	**Availability(m3)**
1951	34	5,300
1961	46	3,950

1971	65	2,700
1981	84	2,100
1991	115	1,600
2000	148	1,200
2013	207	850
2025	267	659

Table 1 Source (PMPIU 2009)

Average temperature of Pakistan will be increased revealed during the studies of several GCMs projects ranging 1.3 in 2020, 2.5-2.8 C in by 2050s, and 3.9-4.4 C by 2080s in correspondence to the global average surface temperature by 2.8-3.4 C by 21st century. Similarly the precipitation is projected to increase slightly during the summer and decrease in winter with no significant change in annual precipitation. It is also projected during the studies that climate change will increase the variability of monsoon rains and enhance the frequency and severity of such extreme events resulting floods and droughts. The most important climate change threats to Pakistan that has been identified are increased variability of monsoon, Glaciers threatening water inflows to the Indus River System. These extreme variable weather patterns could also lead to extreme events such as increased risk of floods, droughts and cyclones and on the other side increased siltation of major dams resulting in greater loss of reservoir capacity. The water storage capacity of Pakistan Compromises of three large reservoirs Mangla (on Jehlum mainly snow fed and monsoonal rain), Chashma and Tarbela (on Indus river snow fed and glacial melt) built in 1967, 1971 and 1974 with total original capacity of 18.37 MAF (Mir, 2010).

1.3.2 Causes of water Losses:

There are several reasons for water losses from conventional non efficient water management practices (Structural, Non structural) to the climate change adaptation policy and population rise. Two major factors have been explained that result in major water losses apart from new practices using drips, sprinklers, pipes and lining.

a) Reduced Reservoirs Capacity:

As due to the process of siltation the capacities of three reservoirs has been reduced with time. The total capacity decreased to 13.68 maf and is approximately decrease more to 13.68 maf in the year 2010.At present on average 35 maf of water flows to the sea annually during flood season, while there is a need to conserve each drop of water. As a result of climate change the intensity of droughts and floods has been increased and there will be even greater need to store the surplus water during high river flow periods (Mir, 2010).

b) Losses due to Non Storage Capacity:

In the recent floods Pakistan has to pay a huge cost with the worst ever damages done by water which can be reserved in a dam but because of political instability and games Pakistan still couldn't manage to build any dam and because of that lost $4 worth of water. According to the chairman of Fauji fertilizer company Pakistan has lost water in the floods due to non storage capacity that could irrigate 40million acres of land and it needs Rs 6 billion worth of water to irrigate 1 million acres of land. On the other hand Economic experts of Pakistan said that we lost Rs 240 billion because of no storage and it's because of political harmony(PTS, 2010).

1.3.3 Integrated options for Water Security:

Dams are a matter of survival for Pakistan to store water and produce electricity but definitely not the only option available. Pakistan always adopted strategies as a defensive state that prefer not to do or invest huge amount on something very new as being a not poor but non affordable state. Pakistan has always relied on Dams and ground water for its water needs and always used structural measures building more dams, canals, dredging etc to mitigate the flood impact but in fact none of these practices are sustainable or environmental friendly .Dams are important but is not the only solution to meet the increasing water demand and flood mitigation .Dams where result in the migration of hundreds and thousands of people on the other hand results in destruction of an ecosystem. According to a report produced by World Commission on Dams states that "During the construction of major dams in Pakistan Like Tarbela Dam the most important elements such as flooding and ecological impacts were not considered"(WCD, 2000:68/105).

2. RESEARCH DESIGN AND METHODOLOGY

Climate change has become a great concern for many countries including Pakistan who has experienced worst ever damages during the recent flooding events. Climate change affected the monsoon pattern in the regions leaving Pakistan more vulnerable to floods and droughts whose intensity has no limit. Rawalpindi which is a neighboring city to the capital city Islamabad and one of the most important urban centers has always been a victim of this urban flash flooding due to monsoon rains at Lai Nullah and during the dry months experience water shortages. To deal with the flood situation regional government uses it's only universal option and in every season starts dredging the Lai Nullah to increase the capacity to cope the volume of flood water. On the other hand increased ground water extractions has lower the ground water table and also effected the water quality that is another challenge for the local government to meet the increasing demand of this major urban center that is growing day by day. The research interest is finding out other integrated options and practices around the world in similar context addressing flood mitigation and water security.

2.1 Research Question:

How to use basic IWRM for understanding a problem and how could it help in choosing better options?

Identification of Integrated options for flood mitigation and water security at Lai Nullah Basin (Rawalpindi) in Pakistan.

The suitable options will be based on from the opportunities and resources present within the study area must as a result mitigate flood impact, is reliable, sustainable, give economic benefits and meet the increasing water demand of growing population and is not harmful to the environment.

2.2 Objective:

The research is focusing on two major aspects within the study area

Primary Objective:

Studying the options used for flood mitigation within the study area during different projects

Looking into water security issues within the study area

Secondary Objective:

Exploring integrated option from the case studies that address both issues address in the primary purpose

2.3 Methodology:

Secondary analysis is a more convenient approach for the research (Szabo and Strang, 1997).Secondary analysis of pre-existing qualitative data has been used to investigate the research question. The reason of choosing secondary data analysis to investigate the main issues of concern in relation to my research question and comparative study of preexisting data from different sources to check the authenticity of information. There are various arguments developed in favor of secondary analysis showing that the approach can bring new knowledge and understanding (Hinds et al, 1997).The main source of secondary data are Project reports by the official or executing organizations, reports, Newspapers, Case studies, research studies, already conducted interviews and surveys.

Choosing Lai Nullah as a main case study is for better understanding of relationship between floods and droughts in context of climate change at small level but the methodology is not limited and can be applied on a larger scale.

Lai Nullah as a main case study has been taken with an assumption that floods and droughts are caused by the selection of conventional, strategies and bad options. The main purpose for taking a case study at small level for better and clear understanding the relationship between floods and droughts and how the selection of options could make situation better or worse.

To know about what options has been used to deal with the situation, different project reports in context with flood mitigation will be studied, specifically the projects completed before 2010 floods and measuring the outputs as a result of the project. Comparing the outputs and analyzing the reports from news papers, Television reports and interviews taken and reported by different sources available online.

Case Study Methodology

In particular case study methodology has been used. Case study based research with the reports from past studies allows the understanding and exploration of complex issues. It is also considered to be a robust research method where there is a need of holistic in depth investigation (Gulsecen & Kubat, 2006).

Different ways and criteria are used for event observation, data collection and analyzing the information. Taking a Lai Nullah as an Investigative case study and using multiple study design by replicating the case through pattern matching that enables the flow of several pieces of information from similar cases to theoretical proposition (Campbell, 1975).According to integrated water resource management the whole water shed and the problems in it as a whole will be taken, making it a complex and multivariate case. Problem solving theory in such a case will help to understand the investigation and multiple data from various sources as a part of collective case study for in depth analysis, understanding, exploring on the other hand will help achieve the objectives of research question (Stake, 1995).

Since IWRM is an important aspect of my research three theoretical concepts of IWRM by Green (2004) will also taken as a base for investigation which includes,

- Catchment area should be taken as a whole and the problems associated in it as a part of land use planning for best use of the catchment as a whole rather than focusing only on minimizing the flood losses.
- Adopting the Integrated Water Resource Management approach can provide new insights which can help us to make better choices.
- Integrated Water Resources Management is a cross-sectoral policy approach, designed to replace the traditional, fragmented sectoral approach to water resources and management that has led to poor services and unsustainable resource use.

This theoretical concept has been incorporated in a design framework in such a way that helps to extract the required information from the case study and organize it systematically to answer the research question.

1. Rich Picture: satisfies the first IWRM concept where catchment area as a whole needs to be taken and un-structuring the problem. This basic idea of this picture comes from Peter Checklands Rich Picture of Soft System Methodology (Checkland, 2000). To draw a boundary

for the problems and to explore them in a systemic way six components were extracted from the definition of IWRM defined by GWP(2000) these components include (a) Governance (b) Land (c) Water (d) Economic (e) Social Welfare (f) Environment.

Available Sources: News Papers, Television Surveys, Project reports

2. Options in Practice: After getting a clear view of flood and drought problems from rich picture project documents will be studied that were completed before 2010 for flood mitigation. Options will be analyzed and criticism will be made against each output of the projects completed in the study area by using the secondary available data and measured the effectiveness of options used to mitigate the flood impact. Case studies will be used as a part of best renowned practices to support the criticism.
3. Ideal Situation Assumption: An ideal state has been defined for the Lai Nullah by removing and reversing all the identified problems within rich picture.
4. SWOT Analysis: is a useful technique to for understanding the strength and weakness and identifying both the opportunities that are open and threats to be faced. In order to see the possibility to achieve the ideal assumed state SWOT analysis will be done.
5. Water Management Transition Framework: is the Integration of Urban Planning along with the management while conserving and protecting the urban water cycle that ensures the management of urban water realizing its sensitivity towards natural and ecological cycles. It will be used as a time line measuring between the case study area and comparative model case study areas.
   (SWOT analysis together with WMTF gave an understanding of impact of options used during different time periods and how far to go)
6. New Options: Now as it will be clear that what are the problems and how the ideal state should be for Lai Nullah with all the resources in hand after SWOT analysis case studies will be explored as a part of best practices and the options used in it that satisfies all the conditions at Lai Nullah.

3. LITERATURE REVIEW

3.1 Concept of IWRM

Access to fresh, reliable and clean water is a basic human right. Managers and policy makers have been managing it since the beginning of civilization in a best possible way as they could. Gradual increase of population and industrialization had threatened the reliable availability of this resource. With the gradual increase of knowledge along with technology and experiences gained the policy makers, managers and researchers found different way to manage this vital source that is more reliable and sustainable. IWRM is a modern approach where all stakeholders share the responsibility and play their role in managing this resource .Global water partnership defines IWRM as "Coordinated Development and management of Land, water and related resources in order to maximize resultant economic and social welfare in an equitable manner without compromising on sustainability of vital eco system"(GWP, 2000). The picture and concept of IWRM is vague and different people and organizations explain it in a different way and using or applying IWRM is a dilemma itself. "Integrated water resources management is not a fixed blueprint of policies and actions with a set ending and a set beginning" (Hassing, 2006).

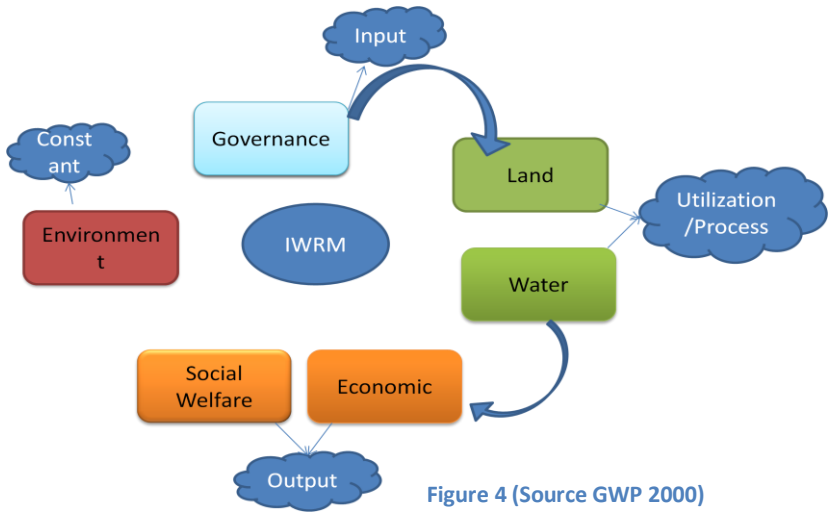


Figure 4 (Source GWP 2000)

IWRM process gives a holistic understanding of water resource management and brings more options to choose as said by Colin Green "Adopting the Integrated Water Resource Management approach can provide new insights which can help us to make better choices" (Green, 2004:12).Integrated Water Resources Management is a cross-sectoral policy approach, designed to replace the traditional, fragmented sectoral approach to water resources and management that has led to poor services and unsustainable resource use. IWRM is based on the understanding that water resources are an integral component of the ecosystem, a natural resource, and a social and economic good.

IWRM is based on four major guiding principles of Dublin significantly contributed to agenda 21 recommendations (Chapter 18 on freshwater resources) adopted at UN conference on Environment and Development in Rio de Janerio 1992(GWP, 2000).

The four Dublin principles and foundation of IWRM are:

- Fresh water is a finite and vulnerable resource
- Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.
- Women play a central part in the provision, management and safeguarding of water.
- Water has an economic value in all its competing uses and should be recognized as an economic good.

3.2 Strategic Objectives of IWRM:

Jan Hassing (2006) a technical coordinator for IWRM Toolbox at Global Water Partnership calling IWRM as a process of change, a new way of thinking about water resource management in order to achieve three key strategic objectives:-

1. Efficiency; maximizing the economic and social welfare
2. Equity; to promote sustainable social development by allocating the cost and benefits
3. Environmental Sustainability

3.3 Complexity and Application:

Even though IWRM has been applied at different levels around the world but still its success depends upon the understanding and the way of implementation that varies in context to culture, topography, politics and related factors. Success of one IWRM case in one part of the world could be a failure in another part of the world. Colin Green thinks that in real world the practical application for implementing and delivering IWRM is a major challenge due to the complexity of institutional working mechanism with different roles and responsibilities. In a real world delivering IWRM is a major challenge; As far as national and regional policies are concerned catchment management has to be integrated and there is different type of institutions responsible for different activities. So based on the local situation what is appropriate to be integrated with a series of strategic and holistic concepts (Green, 2004:12).

3.4 IWRM in Pakistan:

According to the World Water Council, over the past 50 yrs economic losses from weather and flood catastrophes have increased ten-fold, partially as a result of rapid climate changes (Eisenreich, 2005). Pakistan is one of the countries that have been affected by these catastrophes the most. It was based on the lessons learned from flood catastrophes and importance of the issue United Nations General Assembly announced the year 2005-15 as international decade for action against the water related disasters. The experts at water and Environment conference 1992 in Dublin saw the global water picture as critical and set out for principles based on which Integrated Water Resource management (IWRM) approach was adopted. Therefore, at the World Summit on Sustainable Development (Johannesburg, 2002) the main directive was that all countries must work toward instituting IWRM in their own countries and, more specifically, each country should prepare a National IWRM and Water Efficiency Plan by 2005.Based on this Scenario the Government of the Netherlands (GON) requested ADB to support the governments of Bangladesh, Indonesia, Pakistan, and Viet Nam with technical assistance (TA) to prepare integrated water resources management (IWRM) plans in response to the commitments made by government leaders at World Summit on Sustainable Development (Johannesburg, 2002).In the same summit under Agenda 21 ,Section 2 by United Nations(UNCED, 1992)the implementation strategies included the provision and maintenance of waste management services including other services as storm water drainage and water supply to achieve the target that all the developing countries will have their own national program by the year 2010 and the targets for waste reuse and recycling. After extreme climatic impacts resulting severe floods and droughts the efforts were doubled to prepare a new Water Plan at National level to deal with the situation. GWP Pakistan prepared the 10th Five Year Plan 2010-15 on Water Resource Development and presented it February 22 to the Planning Commission of Pakistan for adoption and implementation. GWP Pakistan developed the plan at the government's request and incorporated an integrated water resources management approach (GWP, 2010).

3.5 IWRM partnerships and Projects:

To strengthen the IWRM with in the country and on global level cooperation Pakistan Water Partnership was formed by Naseer Ahmad Gallani in collaboration with Global Water Partnership. Later on area water partnerships were developed for coordinated development and

management within the country (PWP, 2010). Pakistan has sound enabling environment to implement IWRM successfully with available institutions with the presence of sound technical staff at all levels within the country.

During the past few years number of projects at all level throughout based on the concept of IWRM has been started, implemented and completed. A series of projects had been completed based on IWRM in Pakistan to improve the flood situation and policy improvement before the worst catastrophic flood in 2010 happened effecting 17.6 million people that is twice as more as were effected in previous flood in 1992(IEG, 2010:3).These projects are

1. Flood Management River Chinab from Marla to Khanki under Associated program on Flood Management by WMO & GWP;2003
2. Helping to Introduce IWRM in 25 River Basins including Ravi Basin in Pakistan by ADB 2006/2010
3. Process Development for Preparing and Implementing Integrated Water Resources Management Plans financed by ADB & Govt of Netherlands; 2006

3.6 IWRM & Flood Management:

The way we handle the catastrophic floods remains a dilemma that if we see water as a life providing and sustaining element or a destructive force against human and economic development. Flood disasters needs to be addressed in context with IWRM as it adversely affect the sustainability of development(IFM,2005:3).Pakistan has always been a flood control state and using time based approach(Act when something happen) and using on spot options to manage water options with short term objectives. Within the development strategies integrated flood risks for "IWRM needs a paradigm shift from flood control to flood management" (IFM, 2005:3). A paper presentation by Dr.Shahbaz Khan on "Enhancing Social Resilience through participatory integrated flood and drought management in Pakistan" emphasized on global practices on institutional coordination leading to(IWRM)by using modern technology and community empowerment describing how such practices can help Pakistan in managing its floods and droughts(Pamirtimes, 2010).

4. CASE STUDY AREA AND PROBLEM ANALYSIS WITHIN IWRM

4.1 Lai Nullah Flood Basin; A Case Study

4.1.1 Geography:

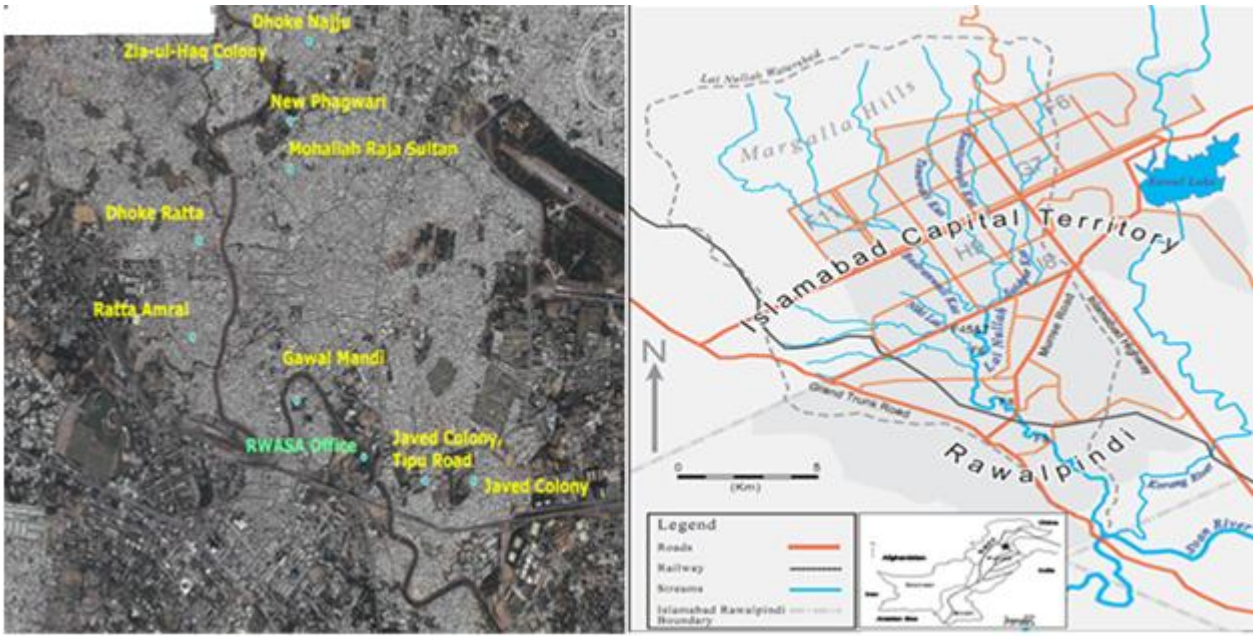


Fig.5 Source (WASA 2007)

Lai Nullah Basin stretching from the Margalla hills in Federal Capital City Islamabad at the North western edge until Soan River at the South-eastern edge in District Rawalpindi of Province of the Punjab with a total length of about 30 Km and has a catchment area of 239.8 Km² (161.2 Km² in Islamabad and 73.6 Km² in Rawalpindi); Three major tributaries originating from Margalla hills (1).Said Pur Khas (2).Tenawali Kas (3).Bedarawali Kas flowing into main stream of Lai Nullah just upstream of Kattarian Bridge,at I.J. Principal Road forming the administrative boundary between Rawalpindi and Islamabad. Within the jurisdiction of Rawalpindi below kattarian Bridge the main stream meets other three major tributaries(1).Nikki Lai (2).Pir Wadhai Khas (3).Dhok Ratta Nullah one after another, flowing through the centre of the Rawalpindi city and fells into the Soan River. Apart from these major tributaries there are other six tributaries or swage/drainage channels which join the mainstream between Dhok Ratta Nullah and Soan River.Lai Nullah flood flows actually contribute to River Soan which is the tributary river of River Indus the largest river among major rivers in Pakistan (Kamal, 2004:04) .

4.1.2 Flood History:

As collected from several study reports indicate that, in the Lai Nullah Basin area, flood has occurred with the frequency of 19 years, at least in 59 years from 1944 to 2002 as may be noted from table below. In other words, flood damage broke out almost once in every three years in the two cities of Islamabad-Rawalpindi of Pakistan

Lai Nullah –Extreme Flood Years

Year	**Date**	**Year**	**Date**
1944	August 13	1985	No Date
1957	No Date	1988	No Date
1966	July 21	1990	No Date
1970	No Date	1994	July 3
1972	No Date	1995	July 24
1976	No Date	1996	July 29
1977	No Date	1997	July 23
1978	No Date	2001	July 23
1981	No Date	2002	August 13
1982	August 10		

Table 2 Source(Kamal 2004)

Among the above extreme flood years, 1981, 1988, 1997 and 2001 had been the worst with 2001 being of highly unprecedented nature. In these extreme catastrophes a total of 74 human lives have been lost, about 400,000 people were affected, 742 cattle head perished, 1,087 houses were completely and 2,448 partially damaged. Estimates indicate a damage/loss of more than USD 0.25 billion to infrastructure, Government and private property (Kamal, 2004:05).

There has been no official data with reliable source on floods in 2010 has been updated for the flood effects and after affects on Lai Nullah basin. But according to general non reliable reports 1000 houses were damaged across the basin and some cases of land sliding but no life loss has been reported(Shazia, 2010).

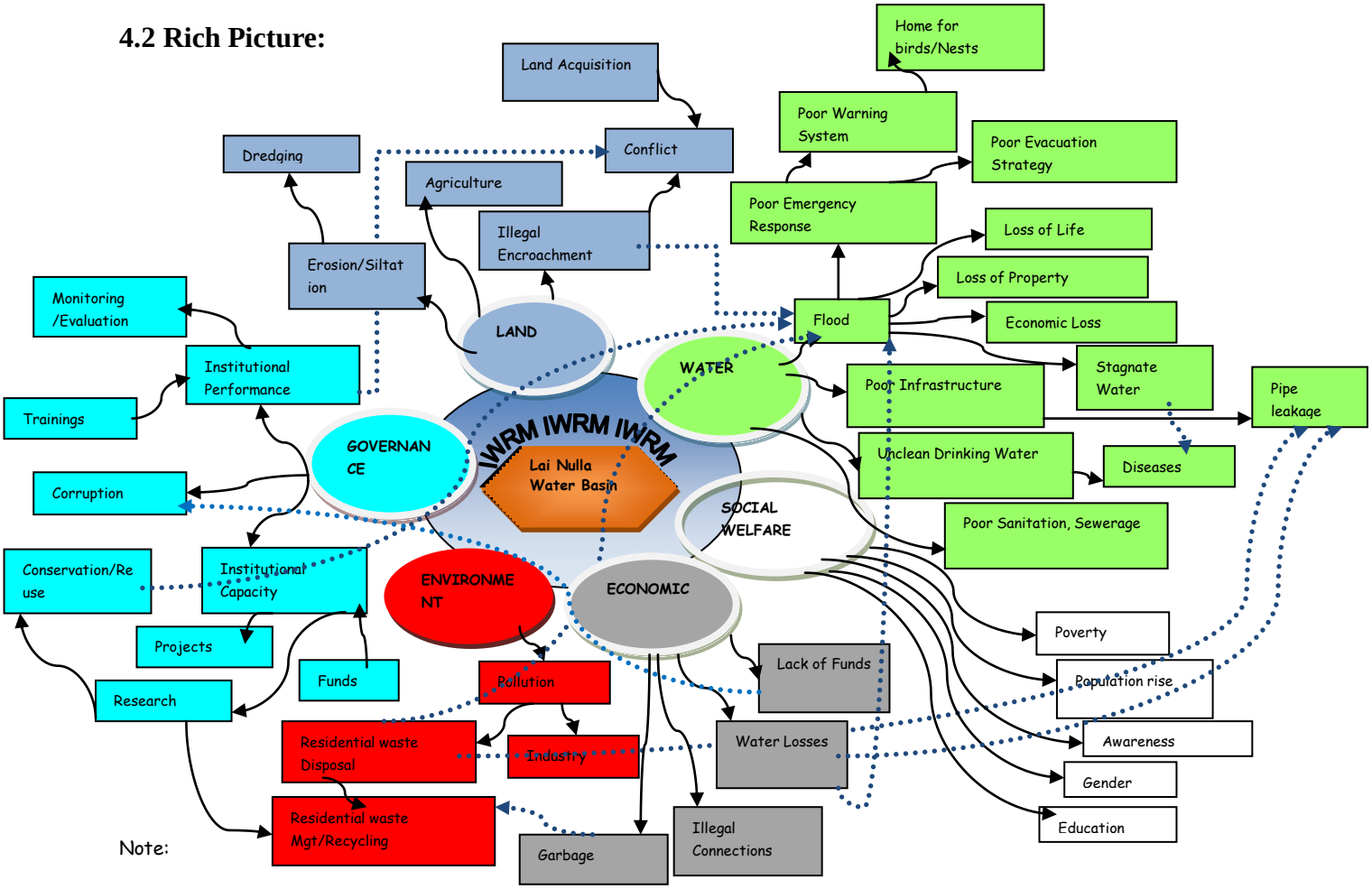
4.1.3 Flood vulnerable areas around Lai Nullah

The following low laying / close to Lai Nullah areas of Rawalpindi city mentioned by WASA officials(Islam-Ul-Haq & Cheema, 2009) are usually affected by the Lai Nullah floods resulting in loss of human life, livestock, and property etc.

- Dhoke Najju
- Zia ul Haq Colony
- Dhoke Ratta

- Ratta Amral
- Tipu Road , Chamanzar , Javed colony
- New Phagwari
- Mohallah Raja Sultan
- Dhoke Ellahi Bakhash

4.2 Rich Picture:



Note:

- Blue Dotted lines show connection between different components
- Black lines with arrow showing the problems related to specific component
- Each component is given specific color

Fig.6 Source (Multiple Secondary)

The figure is constructed around six major components of IWRM that are important in my point of view and includes Land, Water, Governance, Economic, Social Welfare and Environment. As all these problems lie within the catchment area and according to Green (2004) catchment area should be taken as a whole and the problems associated in it as a part of land use planning for

best use of the catchment as a whole rather than focusing only on minimizing the flood losses. These components have been extracted from the definition of IWRM. All the problems constructed around these six components add to flooding and water shortage.

4.2.1 Land

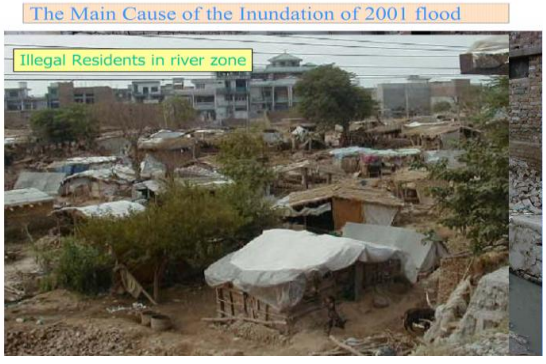
The problems associated with IWRM component of land are Illegal Encroachment within the flood plain, agricultural practices with land leveling and cutting down the trees leaving soil soft and erosive, Dredging the Lai Nullah causing more erosion.

a) Illegal Encroachments:

Increasing population and lack of livelihood opportunities compel many around the country to move to Rawalpindi and especially around Lai Nullah. The right of way of Lai Nullah and its tributaries was encroached due to haphazard urban development at several localities in the city resulting in the blockage of the flood plains of the natural streams. As a result of these illegal encroachments Lai Nullah and its tributaries decreased its width and absence of passages along the sides of Nullah thus storm water drainage has become a real challenge. The land use pattern in the central areas of the city compromises of both commercial and residential. Illegal encroachments has created number of complex problems within the city including the blockage of flood water, inadequate parking, venders and hawkers (REIP, 2004).

b) Conflict

It's not legal to have any construction along the banks of river and tributaries until it's been granted by the concerned authorities and it's not legal to remove the illegal encroachments by the authorities if they are there for a long time. Whenever any project starts the concerned authorities purchase the land from encroachers which are really a tough job to do. (The Nation, 2010) Reported, that the Land that was purchased for the extension of Lai Nullah has been occupied again despite of billion of rupees. The source of The News reported that billions of rupees have been paid to the residents of the area from New Kat Arian to Hamarat Chowk to



extend the Nullah Lai but the responsible authorities have not completed the project even until now and thus people again had started constructing their cottages on Lai Nullah Land because of the negligence of RDA and WASA. Now because of this negligence Lai Nullah will again be filled with wastage of animals and waste material of buildings. Also in this report Director RDA stated that Monitoring of Lai Nullah is the responsibility of WASA. This report and remarks by the RDA director gives an impression of conflict of roles and responsibilities between the executing agencies for the project.

c) Land Acquisition acts and Laws

Policy Framework and Entitlements for land acquisition are based on national laws and policies: (i) the Land Acquisition Act 1894 (amended up to 2003), (ii) the National Resettlement Policy 2002, (iii) the Project Implementation and Resettlement of Affected Persons Ordinance 2001, (iv)the Punjab Development of Cities Ordinance 1981, (v) the Pakistan Environmental Protection Act 1997(ADB 2006)

4.2.2 Social Welfare

Since the population living around Lai Nullah is mostly poor and don't have many good opportunities for education which result in lack of civic sense and awareness issues.

a) Public Participation

This year appeals has been made by (EDO) to the citizens to cooperate with the sanitation department and help in littering the garbage. According to EDO without the participation of citizens the process of cleanliness can't be successful and people should take the social responsibility and not throw any garbage, plastic bags, solid waste into the Nullah as it create blockage in the way of flood water (Daily Times, 2011).

4.2.3 Governance

The complexity of institutions and unclear roles and responsibilities is one of the major governance issues at Lai Nullah Basin and the cases of corruption make it even worse.

a) Institutional Performance:

Many reports showing the inability and poor performance of the institutions and the level of disappointment by the local community is increasing. Federal and Provincial government has spent billions of rupees on management of Lai Nullah but according to the local residents the situation has not been changed much. The road along Lai Nullah due to stagnant water has been cracked. Since the walls of Lai nullah is of mud and sand there is continuous erosion that sweeps along with the flowing water that makes road side narrower and increase the thickness of Lai Nullah bed leaving it more vulnerable to flood. The Height of the bridge over Lai Nullah is about 16ft from which 3ft is garbage and stones. Which means during the monsoon flood season, highly pressurized water will flow under 13ft high bridge which is not a safe sign. The areas around Nullah Lai are Dhoke Najju ,Zia ul Haq Colony, Dhoke Ratta, Ratta Amral ,Javed Colony, Chamanzar, Tipu Road ,New Phagwari Mohallah, Raja Sultan ,Dhoke Ellahi Bakhash and Sultanpora are badly affected by the flood caused by Lai water during monsoon rains in 2010. Muhammad Latif who is one of the residents of Sultan Pura reported that so many applications has been sent to RDA for Lai Nullah Cleaning up and dredging so that water could easily pass through but those complaints are totally ignored. In an interview another shopkeeper near Lai Nullah complained that WASA and RDA they are really not serious about this serious issue and does not clear the Nullah for proper flow. Every monsoon season hundreds of houses and shops are damaged and government never gives sufficient compensation to the affectees (Farooq & Masood, 2011).

b) Corruption:

The Asian Development Bank's (ADB) funded Rawalpindi Environmental Improvement Project (REIP) with its sub components comprising of

- Water Supply Improvement which include (replacement of tube wells, Rehabilitation and reconstruction of distribution network, Installation of water meter and water supply/sanitation facilities in school)
- Environmental Sanitation including (sewage, sewage treatment, Storm water drainage, Solid waste management, slaughterhouse replacement and public toilets)
- Institutional Development

Due to a conflict in one of the subprojects the construction of sewage treatment plant on acquisition of land and slow pace of work by implementing organization (WASA) the project was suspended on Feb 3, 2009 and closed on 31 August 2009(ADB project suspension, 2009).According to (Khattak, 2009) the REIP was suppose to be completed in 2011 but 70% of the work was still incomplete. It is also worth mentioning here that since the launch of project in 2006 the Punjab government has changed four project directors on corruption charges. Contractors had also intimidated to the officials of ADB that the government officials involved in the bidding process were demanding heavy commissions. The half way project left a great mess in the city with open Channels and excavations. State agencies (Anwar & Ahmad, 2010) have been facing lot of challenges in addressing water utilities and struggling to provide efficient and reliable water and sanitation services to the customers. At a moment the state has some crucial issues such as Lack of Sector policy, Poor governance, Weak institutional framework, nonexistent regularity regime, lack of political commitment for reform ,that automatically lead to total failure in service delivery. The poor governance issues are due to technical incapacity, lack of trained personnel, political tensions, no clarity in roles and functions (overlapping), and lack of social accountability.

4.2.4 Water:

The study area (Lai Nullah) is on one side always experiencing high level of flooding during the monsoon season and during the dry period experiences water shortage and insecurity. Where the ground water table is depleting due to abundance use to meet the needs of growing population it is also experiencing water quality issue due to pollution and open sewage disposal by the locals.

The present water supply capacity in the Lai Nullah Basin area is about 785 Million Liters per day in total. Out of the total water supply, the service area of Capital Development Authority in federal Capital, Islamabad shares 507.33 Million Liters per day, while the service area of Water & Sanitation Agency (WASA) OF Rawalpindi city and can its Cantonment share 122.74 Million. The surface water supply capacity of the Lai Nullah is 528.70 Million Liters per day. Principal surface water sources in Lai Nullah basin

come from Simly Dam on Soan River, Khanpur Dam on Haro River and Rawal Dam on Kurang River. Presently the flood water, as it originates from the upper four major tributaries, is not being utilized for any of the urban or irrigation purposes. Rather whatever flood water is generated it goes as waste water to Soan River besides inundating low lying areas. (Kamal, 2004:3/4)

a) Sewerage Network and health issues.

According to WTP (Willing to pay) survey under ADB project (Quo Report Rawalpindi 2006) only 31% of the total households had piped sewage and 66% households drains their sewage to an open channel. In the central part of the Rawalpindi city existing sewerage system serves only 30% of the population and areas near western side at Lai nullah and Nikki lai are completely avoided of sewerage facilities. All this untreated sewage is discharged into Lai Nullah and its tributaries that joins Soan river. This situation has resulted in poor health conditions and wide spread diseases along with the deterioration of surface and ground water within the region. Rawalpindi city does have a Sewage treatment system but does not have proper arrangement for ultimate treatment and disposal of sewage. In 2004 construction of Sewage treatment plant was proposed within in the Rawalpindi Environmental Improvement project (2004). The two main locations around Lai Nullah Satellite town and Khayeban-e-Sir Sayed (Quo Report Rawalpindi, 2006:5-2) sewers were laid its foundation in 1950 and 1970s respectively. The sewage system is combined carrying storm and sewage water. The total length of sewerage system is 137 Km with the total house connections of approximately 80,000.but there is no disposal pumping. WASA has disposal pumping station but these are not being used. Right now raw sewage is discharged into Lai Nullah directly by gravity or through pumping.

b) Water Supply and Quality:

Rawalpindi city first received its piped Water Supply in 1887 (Bromage, 1924) by using the water from Kurang River and then spreading the network of pipelines over the city. At that time the population of the city was 45,000. In 1921 due to increasing population of the city, Municipality suggested to increase the supply of water by trial boar at Saidpur road one mile beyond the northern boundary at 57 feet below ground level. Ever since then there has been rapid expansion and population rise. Number of water supply projects has been implemented in the

past but they were totally insufficient to cope up with the growing water supply demand of the increasing population. Old water distribution network are in last high level of deterioration. Water supply to the population is done on intermitted basis and is unsafe due to undersized and leakage pipes (REIP, 2004).

According to World Bank Report (Quo Report Rawalpindi, 2006) Water supply system for WASA and cantonment is served by following three sources

1. 52,000 m3 per day from Rawal Lake filtration plant is used by Rawalpindi city.
2. From Sanjani treatment plant at Kanpur Dam 60,000 m3 per day goes to Rawalpindi city.
3. 206 tube wells providing 24 MGD from ground water aquifers in and outside the city

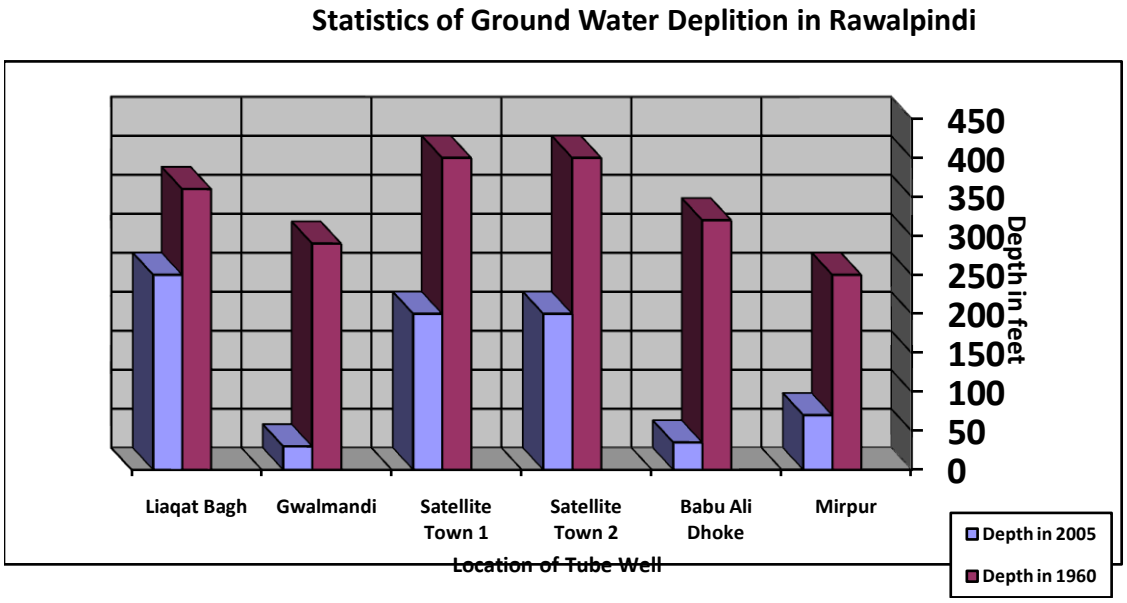


Figure .7 Sources (Islam ul Haq & Cheema 2009)

Around the premises of Rawalpindi the ground water quality is threatened due to industrial and municipal waste. The ground water in the city is depleting due to excessive abstraction. The cost of producing ground water from tube well is about Rs 35/1000 gallons. WASA had estimated future demand within the area of supply till 2010 according to this report in 2006 was (231,846 m^3/day). It has also been mentioned that the extension of water supply cannot be based on further exploitation of ground water as the recharge is low. It was recommended that future resources can only come from the development of surface water and construction of new reservoirs and dams. The two suggested dams in the report were

• Chera Dam, which will give 15 MGD (68,190 m³/day) and

• Dhodhocha dam, which will give 25 MGD (113,650 m³/day).

According to this report these projects were fully government funded and design phase was suppose to be starting by February 2006 by RWSA.

Water Quality Report of 15 Tube wells around Lai Nullah						
Location	**Faecal Coliform Count**	**Hardness as CaCO3**	**Conductance**	**Ca**	**TDS**	**Cl**
A.Nagar TW 71 A	10/100 ml	352	1800	94	522	25
D. Mangtal TW 84	150/100 ml	510	955	136	469	27
D. Mangtal TW 83	36/100 ml	510	1112	132	502	24
D.Hassu TW 88	35/100 ml	510	1210	122	429	23
R.Amral TW 74-B	29/100 ml	412	879	115	511	27
D.Mangtal TW 85-A	45/100 ml	512	1250	136	422	19
D.Hassu TW 89	155/100 ml	480	1125	116	524	23
H.Colony TW 81	22/100 ml	280	1436	93	709	29
H.Colony TW 81 A	200/100 ml	284	1138	90	750	23
H. Colony TW 82	25/100 ml	282	1554	92	781	31
R.Amral TW 74	44/100 ml	334	1462	108	732	29
L.Bagh TW 59	nil/100 ml	320	1329	104	666	27
D.Ratta TW 76-B	10/100 ml	332	1348	108	675	27
Chaman TW 60- B	50/100 ml	320	926	104	463	19
Arya, M TW 58-A	20/100 ml	318	1143	102	571	23

Table 3 Source(Islam ul Haq & Cheema 2009)

All the tube wells installed near Nallah Lai, as shown in figure are producing contaminated water. Yearly water table depletion matrix (10ft per year), showing a concern of future water demand of the city (Islam-Ul-Haq & Cheema, 2009).

According to RWASA Water quality report (2003) Out of total 240 tube wells 72 has been producing biologically contaminated water which is on increase. The main reason for this contamination according to Islam-Ul-Haq & Cheema (2009) is recharge mechanism of Lai Nullah and Korang River that are carrying water of 0.545 million m3/day.

4.2.5 Environment:

a) Garbage and Waste Disposal:

Garbage and Waste Disposal in the Lai Nullah is one of the most important environmental concerns. According to (Islam-Ul-Haq & Cheema, 2009) Waste and Garbage disposal in Lai Nullah is mother of all issues from causing floods, water quality to health hazards. To tackle this problem is not only the social responsibility of people living around but city District government which is suffering from operational, technical and financial issues. Its only 60% of the generated waste that is been collected and less than 50% is disposed off in unhygienic way. With the increase in population the situation will get worse in the coming years. Due to the equal neglect of responsible institutional staff and public concern of where to dump garbage is kept thrown in Lai Nullah without any civic sense and institutional arrangement. This not only creates health, unhygienic and environmental problems but is a major cause of monsoon floods due to blockage of drains and sewers. (Sabzwari, 2006) estimates that Rawalpindi alone produces about 141,000 cubic meters of sewage. This is expected to increase to 272,000 cubic meters by 2025.

b) Recycling:

Like all the developed countries that learned the importance of going green and recycling now Pakistan has taken a major step on Lai Nullah to make money out of garbage. The city government of Rawalpindi given a task to a private company WMP (Waste Management of Pakistan) to generate fuel from garbage after buying it daily from the city government, in a way city will get cleaner. The company will install Waste convertor technology in Rawalpindi generating refuse derived fuel (RDF) from municipal waste. The district administration will sell the garbage to the company at Rs 50 per ton. The total waste generation is about 800 tons daily, which means the district government will earn Rs 40,000 a day once the company starts its operation. Mohammad Usman, a consultant to UUP, mentioned that this RDF plant can separate combustible wastes from non combustible ones and can convert the entire garbage of the Rawalpindi city to energy with fertilizer as a byproduct. Rawalpindi's district administration will sell garbage to the company at Rs50 per ton. The total generation of waste in Rawalpindi city is around 800 tons daily, which means the district administration would earn Rs 40,000 a day once the company starts its operation. Mohammad Usman, a consultant of UUP, told Dawn that the

cost of RDF plant was Rs80 million and it can separate combustible wastes from non-combustible ones. “Importantly it can convert the entire garbage in the city into energy on daily basis with fertilizers as byproduct” **(**Khattak, 2011).

4.2.6 Economics

Flooding and related problems are directly or indirectly have a major impact on economical condition of the area. Loss of life, loss of property, damage to infrastructure is an overall economic loss and failure. Suspension of Rawalpindi Environmental Improvement project and frozen funds where left all the work half way (Khattak, 2009) has resulted in economic loss, since the completed project was supposed to add more supply schemes in the city adding more revenue to the authorities.

a) Financial cut off

Lai Nullah is already a victim of insufficient funds and for the financial year 2010-11 there has been 39.85% less allocation of funds for the water sector, where the allocation of Rs 22.883 billion for 64 projects, that are mostly on surface small dams, delay action dams and renovation of old water infrastructure(Javaid, 2010).

b) Illegal Water Connection

Where leakage through the supply pipes is a major loss authority are facing. Increasing illegal connections and use of pumping motors to get extra supply by the resident’s turns out to be reduced taxes, unequal share distribution and loss of resources. There have been complaints that illegal connections are provided by the water supply staff on bribe (Frontier Star, 2011)

5. Projects and Flood Mitigation Options Used

Lai Nullah which had experienced 19 floods in 54 year period from 1944 to 2002 and now with the catastrophic flood of 2010 the number rise to 20 .Policymakers and engineers started many different projects since from the very beginning for flood control and are always concerned for the sustainability in this important basin due to its geographical location as it lies in the two most important cities of Pakistan from Islamabad that is the capital of Pakistan and Rawalpindi (Kamal, 2004:05).

1. Project for Strengthening of Flood Risk Management in Lai Nullah Basin by JICA 2007/2009 US$5.9 million(Completed)
2. Asian Development Bank-funded Rawalpindi Environment Improvement Project (REIP)2006 $85.7 million(Suspended)
3. Lai Nullah Dredging 2010/11 by WASA Rs.47 million(Completed)
4. Construction of Lai Expressway and Flood Channel Project 2008 – 2010 Rs 4billion(Not Started)

It is a pity and sorrow that out of these four major projects only two were completed and the two completed projects didn't give the premising results. Out of these four projects only two has been completed.

Analysis of the flood mitigation options used during the two projects

5.1 Project for Strengthening of Flood Risk Management

The Study on Comprehensive Flood Mitigation and Environmental Improvement Plan for the Lai Nullah Basin (the Master Plan Study) was undertaken by the Federal Flood Commission (FFC) of the Ministry of Water & Power (MWP), through a technical cooperation provided by the Japan International Cooperation Agency (JICA) during the period May 2002 to September 2003.In 2007 Flood Forecasting and Warning System (FFWS) by JICA was completed, later on in 2009 the Project for Strengthening of Flood Risk Management in Lai Nullah Basin was successfully completed.The overall Goal of the project was to mitigate the flood damage and victims in the target area with a purpose to build a system and structure that enables mass evacuation at the event of floods. The three major outcomes were expected after the project (Inception report, 2007)

1: Capacity of PMD is strengthened enough to utilize flood early warning system effectively and issue warning properly.

2: Capacity of local authorities is developed enough to promote people's awareness and preparedness for the floods.

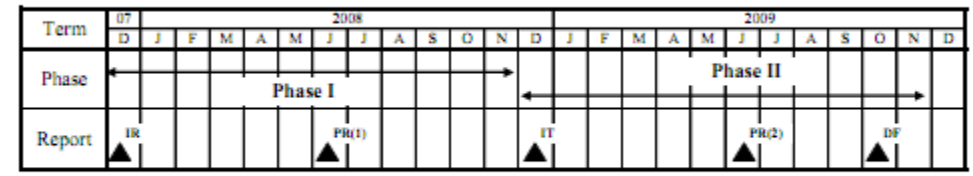
3: Capacity of related organizations is strengthened enough to mitigate the damage offload.

5.1.1 Time Line:

Project was executed in 25 months in two phases as mentioned in the fig

Phase I : Twelve (12) moths From December 2007 to November 2008

Phase II : Twelve (12) moths From December 2008 to November 2009



Legend: IC: Inception Report PR: Progress Report IT: Interim Report
DF: Draft Final Report F: Final Report

source: Inception report 2007;http://www.pakmet.com.pk/nl/inception%20report.pdf

Federal Flood Commission (FFC) was mainly responsible for administration and coordination of the project. City government and PMD were acting as principal counterparts that were suppose to accept the technical transfers and primarily carry out the project in cooperation with Japanese experts and other related organizations.

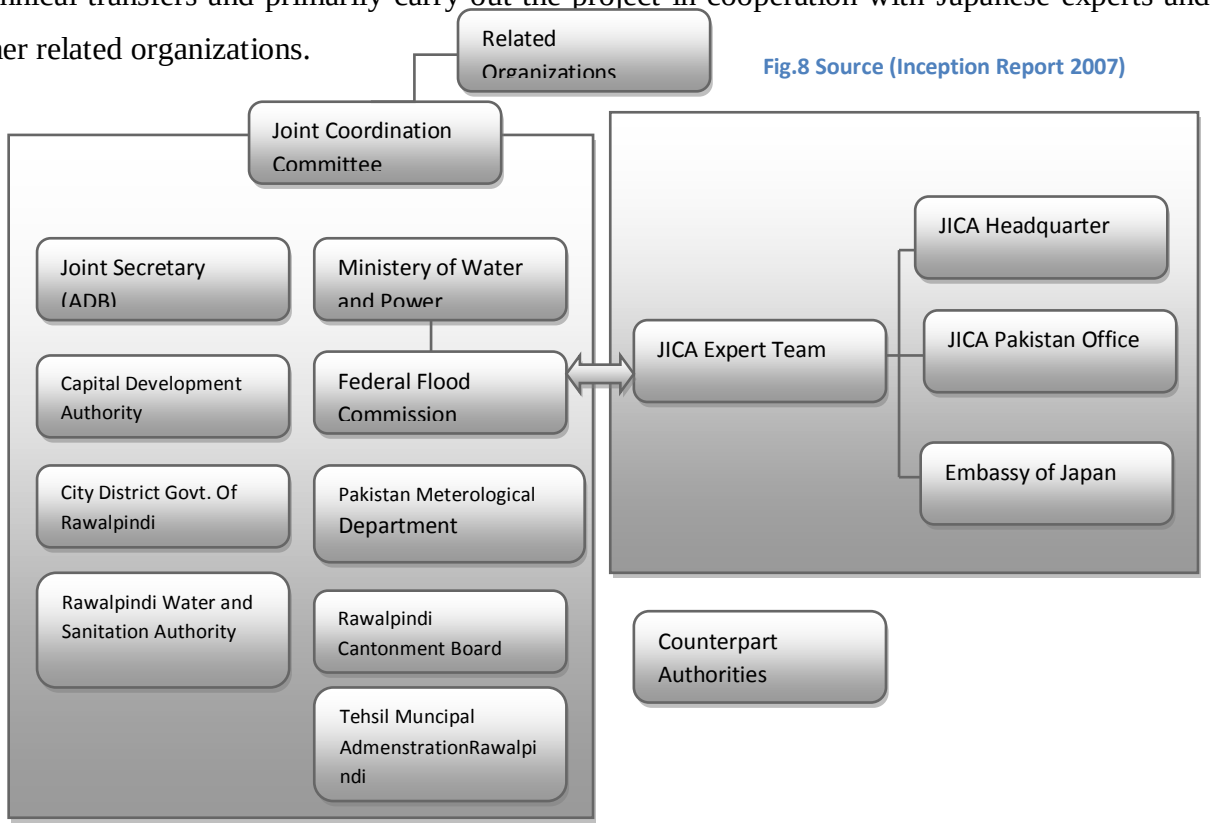


Fig.8 Source (Inception Report 2007)

5.1.2 Joint Coordination Committee:

For successful and effective implementation of the project JCC was established in coordination and cooperation with flood relief committee to fulfill the following functions.

- Reviewing the progress of the Project
- During the implementation of the project, discussion and exchange of views on major rising issues.
- To evaluate PDM during the course of the Project and suggest revision, if necessary.
- Any other related issue

5.1.3 Criticism and concern

The findings of FFWS project itself was a way forward and was requested to be included in this continuing project. The major problems identified after a survey by the project team on monsoon season with the locals were like

- Never heard about warning siren?
- What is the meaning of warning siren?
- Where is the flood relief centre?
- How to go flood relief centre?

a) Output one and Criticism

Capacity of PMD is strengthened enough to utilize flood early warning system effectively and issue warning properly?

The main component of the project was Flood forecast, warning and preparedness. Capacity of all the concerned institutions was developed so the proper warning is issued and people are aware what is happening and how should they respond but again this year according to the national news paper **(**Dunya News 2011) flood warning was launched when water level reached to the maximum level.

Second problem that came across was the operation and maintenance of the system and warning equipment as according to the local people reported in the local news paper that the warning siren is now a home for birds and their nests and no measures are being taken to prevent this.Along with Lai Nullah flood warning system and sirens has been installed to warn people

against the flood situation especially during monsoon. Its proper Operation and maintenance around the year is also important and essential. The residents had a concern that throughout the year authorities' negligence to this warning system results in the occupation of birds and their nests that could result in its non functionality when required and such a waste of expensive equipment. People are also concerned that every year birds make their nest inside these sirens and lay eggs and the concerned authorities destroy these nests at a time when the young birds even don't have flying wings. It's really painful and against animal rights. They could do remove the nests at earlier stages to avoid this situation or also can cover the sirens with a net to prevent from the access of birds to make their nests. District Officer Civil Defense, Tayamman Raza also agrees with the fact that warning system is of sensitive nature and ensures the removal of bird nests (Iqbal, 2011).

b) Output two and Criticism

Capacity of local authorities is developed enough to promote people's awareness and preparedness for the floods?

There is overall lack of information that what was the strategy and preparedness of locals after the completion of the project. The evacuation drills conducted as preparedness of floods within the project didn't work because of panic and lack of continues communication among the concerned people. The project was completed in 2009 and there was no strategy or way forward leaving the community living around vulnerable to the flood situation and the questions like where? When and How are still there. According to (Hassan, 2011) all the concerned agencies and authorities were pre informed about the flood situation and were ready to deal any kind of situation. From the blogs and other semi reliable sources it is clear that authorities had a very weak link with the community and authorities took all the responsibility to deal with the situation.

c) Output three and Criticism

Capacity of related organizations is strengthened enough to mitigate the damage offload?

Even though this project was completed in 2009 with a promising results and confidence that the project was a success but mega flood in 2010 which was a catastrophe for the whole of Pakistan and the management could not be held responsible due to the magnitude and panic caused by massive flood. But the questions of concern arose this year in monsoon flood July 2011 where

not only there has been a huge damage to the assets but two innocent lives were taken by the flood including a child stated by national newspaper (The News, 2011). After the flood the help and concerned organizations were there to take care of the situation.

5.1.4 IWRM aspects of the project:

Project for strengthening of flood risk management is not a single project but a series of JICAs intervention during the period of time in three phases starting with a) Flood mitigation and environmental improvement plan From 2002 to September 2003 to b) Flood Forecast and Warning system in 2007 c) and then this project for Strengthening of Flood Risk Management in Lai Nullah completed in 2009. Structural and non structural measures had been taken but more focus was on soft component. The balance between both components could result in mitigating the floods. The structural components have been described in Upper Mississippi river basin management as best practices and the recommendations and future focus were on equal balance of structural and non structural measures. The 20th international congress on "Irrigation and Drainage" Participatory IWRM was considered essential for sustainable development. Government, management agents, WUA, farmers and other stakeholders need to be grouped together to achieve the common objectives such as efficiency, sustainability, productivity and profitability. From the past experiences it is clear that government itself can't make a change to achieve sustainability, efficiency and profitability without the active involvement of all the stakeholders. Transfer is also an important component within participatory IWRM meaning transfer of responsibility and ownership of parts from the government (Zhanyi, 2008).

a) Lessons Learned: Upper Mississippi river basin

During the 1993 flooding Upper Mississippi river basin was mostly affected. There are three main components of Upper Mississippi including a) Flood Control reservoir b) Flood walls and c)and agricultural levees. There are about 60 flood control reservoirs and 1,600 levees unlike at Lai Nullah which has none but suggestions have been put forth to the authorities within different projects.95% of the levees are agricultural relatively low levels of flood protection. The remaining 5% are urban flood walls built to a very high level to protect cities and towns against floods of great magnitude.

When the performance of a flood control system such as this is evaluated all three components must be considered as a whole and not evaluated as separate feature. This shows that the flood system in 1993 reduced potential flood damages well by 50%. A private river conservation organization by the name of American Rivers took the position that role of federal government in flood management should be reduced and the resulting savings in funds should be dissolved in local governments. It was also mentioned that existing levees and structures was more like a problem rather than a flood solution and supported a non structural approach in the future. An authorized study carried out by representatives of different state and federal agencies confirmed that the structural flood control component was an important part of flood management and stressed that flood plans would be best managed in long term through the combination of structural and non structural measures applied in a reasonable manner that recognizes the risk of occupying flood prone areas (Lovelace & Strauser, 1993).

5.1.5 Way Forward:

Learning from the mistakes, investing more in the IWRM based projects, structural and non structural management, transfer of responsibility and sense of ownership is a way forward. According to (Fahmy, 2008) the primary step for integration is conjunctive use and water resources system element. Conjunctive use and operation of the water resources system elements is primary step for integration. According to him one of the most important factors to achieve the widely accepted approach of IWRM is planning and design.

Now recently started with its new phase where it will not be involved in flood mitigation project but will support UNESCO to implement the project throughout the country. As a way forward on working with Lai Nullah from 2002 till 2009 step by step projects and lessons learned, JICA (JICA Press Release, 2011) had signed a grant agreement of Japanese Yen 284 million with Nations Educational, Scientific and Cultural Organization (UNESCO) for "the Strategic Strengthening of Flood Warning and Management Capacity of Pakistan". The amount will be spend on following three major pillars

- Strategic augmentation of flood forecasting and flood risk and hazard mapping capacity.
- Knowledge platform for sharing trans-boundary databases and community flood management information.

- Capacity development for flood forecasting and hazard mapping.

According to JICA It's a holistic project that will develop the country's capacity in an integrated way reducing human and socioeconomic impacts of flooding and building partnerships.

5.2 Project Dredging of Lai Nullah by WASA

Before every monsoon season the Lai Nullah is filled with garbage, construction material and erosion that block the water flow and coping capacity of the stream during the flood. The maintenance of the channel is the responsibility of WASA water and sanitation authority.

The only official dredging report found at Lai Nullah is from government website (WASA, 2009) and includes only pictorial and not descriptive. Dredging (Excavation by increasing the depth and width) is one of the major issues of concern at Lai Nullah as authorities takes it as a solution to a flooding problem without taking into consideration of environmental and land use impact.

5.2.1 Amount Allocation:

a) Dredging in the year 2009

The total amount of 91million has been allocated by WASA for the complete cleaning and dredging of Lai Nullah along with the grand operation against the encroachments to avoid flooding during the monsoon (Balochistan Times 2009).

b) Dredging in the year 2010/11

The Budjet of Rs 47 million was approved by WASA for cleaning and dredging of Lai Nullah for the year 2010/11(Daily Times Aug12,2010) with another 5million from the government of Punjab (Dredgingtoday Jun 22, 2010) making it combined total of 52million project only for the year 2010/11.

5.2.2 Time Line:

Time Line :Lai Nullah Dredging 2009 till 2011(Source WASA, Balochistan Times, Daily Times, Dredgingtoday)			
Start Time	End Time	Amount Spent	Work Progress
21 May, 2009	20 June,2009	Rs.91million	Completed
June 2010	June 2011	Rs.52million	Completed

According to WASA Deputy Director Zahoor Dogar (Daily Times 27June, 2011**)** Lai Nullah Major Focus had been on low lying area that has been cleared from solid waste and silt and the Nullah has been further widened and deepened to save the city from flood devastation. Also at Aamar chowk section of Lai Nullah work is in progress that will be completed before monsoon.

5.2.3 Public Concern:

People living the low lying area who are always affected by the flooding approach the concerned organization to take effective measures every year. One of the news papers reported (Dredgingtoday 16April, 2010) that In the Low Lying area of Lai Nullah the residents expressed their fear for flood if dredging of small channels is not done. Residents had complaint that channels of Lai Nullah has been dumped with garbage and polythene bags have not been cleaned for last six months, which has blocked the way of water. This matter has been brought in notice of WASA but no action has been taken.

5.2.4 Dredged Material:

A survey conducted by one of the national private news channel showed that all the dredged material and garbage that has been taken out from the Lai Nullah during the project is left and spread over the side banks that not only case severe environmental and health hazards but also erodes backs into the Lai Nullah during next monsoon (Waraich, 2011).

5.2.5 IWRM Lessons Learned: Case Study of West Virginia Dredging:

Dredging as a long term solution for flood mitigation has proven to be neither effective nor cost efficient. The dredging is West Virginia is usually done by using bulldozers, end loaders and other excavators to remove sediment deposits and rock material. The dredged material is used to raise the level of the floodplain area or used as construction material. In more common case the

dredged material acts as a levee. The case study itself explains that if the dredging is meant for flood mitigation and to increase the carrying capacity of the stream the dredged material should never are deposited on the banks where it can easily reenter the stream. There have been examples where dredged material in the past has been used unwisely to construct levees that has limited or no flood resistance.

This case has too many similarities to the Lai Nullah flood basin as after every flood state responsible agencies receive calls from landowners and locals insisting that their stream should be dredged as a quick solution to the flood problem without considering that how the dredging can influence the hydraulic and ecology of the stream. Instead of asking for more dredging there should be a question *"How to restore the stream or to modify it to a condition where it will reduce the impact of repeated flooding"*

There are several examples where the dredged material has been beneficially used to create industrial or recreational purposes. For Example dredged material from Elk River (Charleston) has been deposited along the Kanawha River to develop the Magic Island and some of the material has been used to raise the level of industrial property in accordance with flood plain management ordinance (Appendix H, 2004).

6. DISCUSSION:

6.1 Ideal Situation Assumption for Lai Nullah

An ideal situation for Lai Nullah is a land use planning where Lai Nullah adds esthetics to the city while garbage is recycled and the rain water during the monsoon is harvested and used in such a way that not only mitigates the flood impact but recharge the ground water.

6.2 SWOT Analysis

SWOT Analysis to have an insight of basic resources available to achieve the Ideal Situation at Lai Nullha.

6.2.1 Strength:

Institutions, Flood Warning System, garbage recycle company, basic infrastructure, educated people, International support and funds, equipment, technical staff, public willingness

6.2.2 Weakness:

Corruption, Depleted ground water, Law enforcement for encroachments

6.2.3 Opportunity

Rain Water, Garbage recycling, existing examples of rain water harvesting

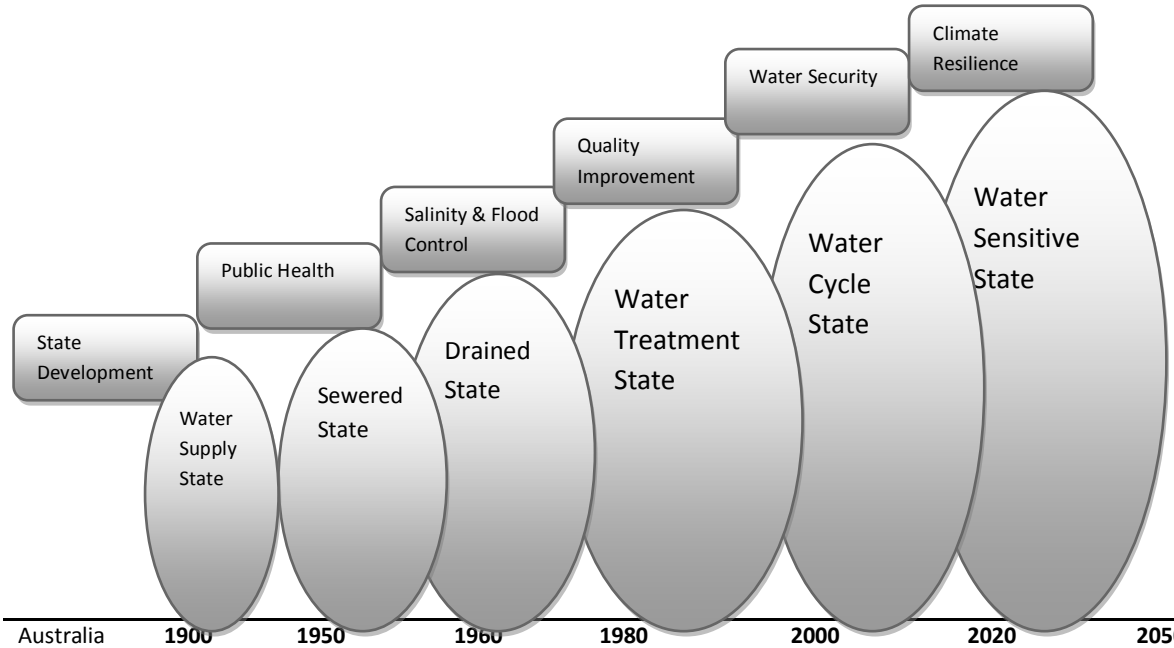
6.2.4 Threat:

Corruption, Lack of Funds, Lack of research, government instability

6.3 Water Management Transition Framework

The water management transition framework gives a vision of where a certain region is standing and how much to go. The Urban water sensitive city (WSUD) is defined as the integration of Urban Planning along with the management while conserving and protecting the urban water cycle that ensures the management of urban water realizing its sensitivity towards natural and ecological cycles. The three major pillars (Wong & Brown, 2008) of that drives towards development and practice of water sensitive city are (a) Under the diversity of centralized and decentralized infrastructure access to diversity of water resources (b) Ecosystem service provision (c) For sustainability and sensitive behavior Socio-political capital. Since, the

conditions are not similar all over the world so according to (Wong and Ashley, 2006) WSUD concept is an interdisciplinary physical and social science accounting for context and people.



Australia	1900	1950	1960	1980	2000	2020	2050
Rawalpindi	1887		2010				
	Town &Country Network	Sewers & STEDs	Rural & Urban Drains	Water Treatment Plant	Fit for Purpose	Adaptive Sustainable Management	Cities as net contributors to Water Cycle
	Water Supply	Sewage Treatment	Flood Mitigation	Environmental Protection Salinity Control	Water Conservation Catchment Management	New Water Product	

Fig.9 Source (Wong & Brown 2008)

The urban water transition framework presented is a conference series by Brown et al (2008) Transitioning to water sensitive cities. Historical, current and future transition states had been shown in this figure modified from the original by adding real timeline for all the states within Australia. This transition framework presents a typology of cities within different states moving towards more sustainable future with service delivery and dominant sociopolitical drivers. All the six transition states are integrated in a way hydrological contract in previous city state influences and shape the next transition state. The negative impact of discharging storm water runoff into coastal environment, water channels and lakes now has been better understood in a holistic way. Catchment water management programs from the mid 1990s to 2000 have achieved impressively with the support of Australian communities (Brown, 2008).

6.3.1 Rawalpindi lagging way to behind

With the basic study and situation analysis if the same model of Transition Framework is compared with Situation and development within Rawalpindi it lies in a stage where all the focus is on flood mitigation so it still lies in Drained state in the year 2011 where Australia was in 1960s. But this state cannot be taken as standard as due to varying factors. As Australia started working towards its sewage treatment in 1950s but in Rawalpindi still there isn't any sewage treat plant and also the water treatment has been started in 1980s within Australia and in Rawalpindi there are treatment plants functioning.

People of Rawalpindi have so many hopes with Asian Development Bank funded (RIEP) Rawalpindi Environmental Improvement Project that already has been suspended due to corruption cases and conflicts. Even the project completes Rawalpindi will stand in 1980s as compared to Australian Development as non of the project objects leads to Water Cycle state and remain in water treatment state.

6.3.2New way of thinking and Managing

It's a sorrow after spending billions Rawalpindi moving backward. It's a time when the managers should think of moving towards water sensitive state and choosing better and reliable options for flood mitigation and increasing urban water demand.

6.4 Rain Water Harvesting

Every Monsoon Rawalpindi experiences so much rain that could be harvested (Kumar, 2000) the concept of rain water harvesting is not so modern but is believed to be in practice for thousands of years. In India it is as old as 5,000 yrs and the city of Dholavira of the Indus valley civilization was practicing rain water harvesting in the dry desert of Thar."The phenomenon of rain water harvesting can be defined as collection of water from surfaces where it falls and storing it for later use".

6.4.1 Is Rain/Storm water drinkable?

Untreated storm water is not recommended for drinking it must go through a various rigorous quality controlled treatment process to ensure it is fit for human consumption. In Adelaide drinking water is carefully monitored and processed in large water quality treatment plants with strict standards.

The urban storm water passes through the variety of landscapes including residential, industrial, parks, gardens, roads is sourced. The urban pollutants carried through the storm water varies in toxicity so it better should be carefully examined and treated. At points where harvesting is feasible with its storing, treating and reusing options it better must be utilized for non potable purposes (Govt of S.Australia, 2009).

6.4.2 Basic Concept for Rain Water Harvesting and Reuse:

With the increase in population and industrial revolution the urban size has been expended. The cities now need huge amount of water and generates large amount of sewage as well as the increased storm water needs a new management approach as stated by Newman as "Big pipe engineering approach" to bring the drinking water to the city and removal of storm and waste water became the standard water management technique (Newman, 2007).

Most of Australia despite being the driest continent its cities located along the coastal receive adequate amount of rainfall each year to satisfactorily cope up with various water demands. For instance Sydney generates 420GL of storm water every year. It has a demand of 660 GL, rain water could boost the plus for the demands of metropolitan area. Rain water harvesting really could reduce the water consumption.

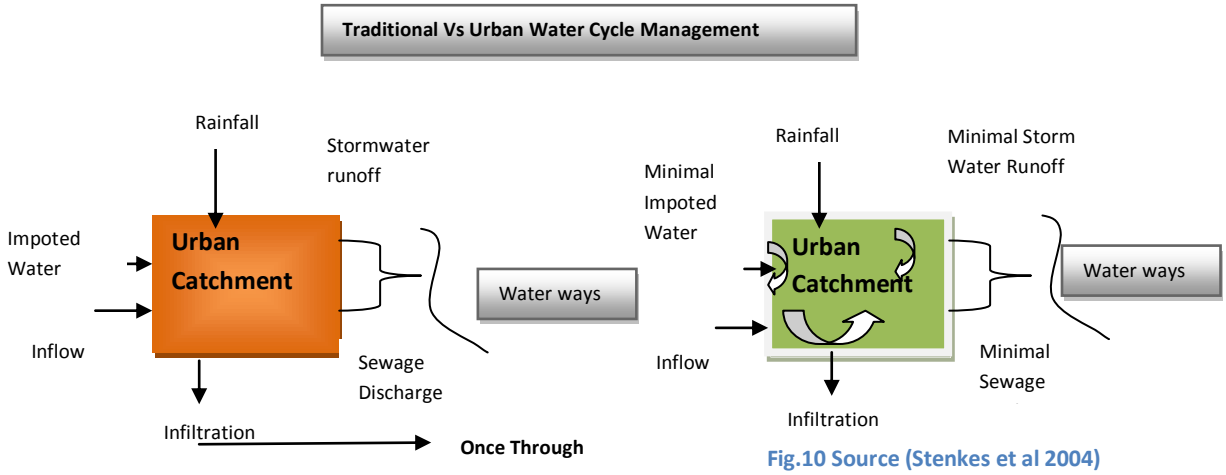


Fig.10 Source (Stenkes et al 2004)

In Australia the centralized system is based on sourcing huge quantity of water from one location, treating and distributing it for use and then finally disposing it to the waste stream at another location (Argent, 1995).

With the increasing climate change pattern it is well acknowledged (Stenkes et al, 2004) that traditional water management paradigm is no longer a way to future sustainable water management where the main focus is on meeting the demand for water by increasing the supply and disposing storm and waste water to prevent the disease spread. Sustainable water management needs initiatives such as rain water harvesting and reuse.

As this approach explained in the figure not reduces the amount of water imported for urban use, it also treats storm water runoff and sewage and cutting off its wasteful discharges into the water ways.

The kogarah town square re developmental project is one of the best examples for rain water collection, treatment and reuse by

1. Collecting rain water and reusing it for low quality uses such as toilet flushing, irrigation and car washing
2. Reducing the water demand through conservation
3. Managing the quantity and quality of storm water, through capture ,reuse and treatment

At Kogarah town square 85% of the rain that falls is collected onsite for reuse (Chanan et al, 2004).

6.5 Two Efficient Integrated Options for Rain Water Harvesting and Reuse:

Two methods for rain water harvesting will be explained one by one as a part of best options available to deal with water security issues in a long run based on all the components of IWRM.

6.5.1 Water Sensitive Urban Design (Example from Australia):

South Australia (Govt of S.Australia, 2009) is now renounced for its waste water recycling and storm water capture and reuses minimizing the flood damage and efficient use of water. The government in South Australia worked innovatively to maximize the availability of water resources and as a result was acknowledged as leaders in recycling treated waste water and storm water capture and reuse and got the highest per capita rainwater tank ownership in Australia and now on its way to become water sensate state. Hon Paul the minister for river Murray thinks that Australia had witnessed severe climate impacts due to climate change and such events will continue to happen but we need to adopt a strategy to mange droughts and floods in order to

minimize the effects on our communities while ensuring that the natural system receives enough or adequate flow to remain healthy. The rain water must be captured and stored for reuse when it's in abundance and urban centers should be designed to provide water security for future generations. In September 2010 Mr. Hon started a Storm water task force that agreed on four major objectives

a. Managing water in an integrated way
b. Mitigating floods risk in a better way
c. Clarifying roles and responsibilities
d. And moving towards water sensitive urban design

The strategy outlining on how to achieve these targets through, integrated water resource management. Experiences had shown that waste water and storm water should not be managed independently and flood mitigation measures must be incorporated within the urban design.

a) Need for Storm water Capture in Australia:

According to Water for Good there is a possibility of climate change impact resulting in more drought conditions and non reliable rainfall. According to CSIRO it could undergo an overall decline in rainfall of between 15% and 30% by 2050 and reduction in runoff. There could also a prediction of flooding and heavy falls. Prolonged warm weather result in increasing water demand and consumption and more intensive or regular storms increases the potential for

1. Severe flooding with economic and property loss
2. Decrease in water quality
3. Channel erosion and sediment load rise within watercourses
4. Vegetation loss through erosion
5. Damage to aquatic habitat

With the increase in population more water will be required for sustaining and urban development. The futuristic approach of storm water management need to focus on water cycle management as a whole and integrated land and water management through water sensitive urban design. This needs catchment based approach integrated with the planning process and needs to be considered with wide range of other components including property, precinct, catchment and regional. To make Adelaide a water sensitive city all this needs to be put in

consideration which will result in minimized flooding with productive utilization of harvested water and optimization of environmental outcomes for urban water ways and costal environments.

b) Water sensitive urban design (WSUD)

It is an integrated approach for urban planning, design and management of total water cycle into developmental process and land use planning. Technologies such as permeable surfaces can be used to reduce runoff and allowing natural ground water recharge and in such way water movements could be slower down from heavy rainfall thus reducing floods. WSUD include features such as wetlands and bio-filtration for cleaning the water by biological means that's flowing through the urban landscape. In water sensitive city one should expect urban development within vibrant water based approach complementing sustainable water management from diversity of sources. In a longer strategic cycle Adelaide's wastewater could be blended with storm water after treatment to support food production close to or within populated areas.

c) Storm Water Use:

Historically storm water was always been tackled as a drainage issue particularly in controlling and mitigating flood. Today it is acknowledged as important component of water resource needed in a water sensitive city. According to a study storm water schemes in 2009 produced 6 gigalitres a year (GL/a) of captured water. And 11 Gl/a was expected to be harvested in 2010 and the target set for 2013 has been set to 20GL.a, however long term target is set to be 60GL/a by 2050 subject to economic and technical feasibility.

Typical Projects based on Storm water requires adequate investment and harvesting requires substantial treatment, a suitable storage option and a new third pipe line distribution to the consumers. The cost to benefit ratio is generally very high.

d) Need based investment (fit-for-purpose principle)

It is also important to understand that how the storm water is going to be utilized, either for drinking purpose where it needs greater treatment measures or for irrigation purposes. Storm water harvesting and reuse projects in particular should be carried out where demand exists or where realistic demand for future is expected. According to the centre for water sensitive cities, Treatment technologies to harvest storm water should be selected by applying fit-for-purpose

principles, with sustainable treatment technology given preference. It bears various benefits for example using low quality for irrigation reduces the significant demand on potable water supply. Apart from that there are more savings on energy and treatment to lower quality level.

e) Reducing Flood Risk:

Managing water in an urban landscape is not an easy task. Where the policies are set to capture and reuse the storm water the flood events in Australia had also raised a concern of public safety and property. Even with increased rain water harvesting depending on the region and topography extra measured are required in flood mitigation.

Areas that are already well established, storm water and its impacts such as flooding needs to be managed. In managing such kind of system there are always administrative, financial and technical challenges. Australia's existing flood mapping shows that in a one in 100 year flood event, up to 8500 buildings(Including residential and non residential) could be affected and of those 7000 buildings are in greater Adelaide and approximately 5000 are in Brownhill-keswick Creek catchment. The catchment is currently developing a storm water management plan under the direction of storm water management authority. This plan will expose the catchment behavior and its specifications in detail and illustrate needs and actions for flood mitigation risks. There is no doubt that it will cost high and will require a holistic integrated approach.

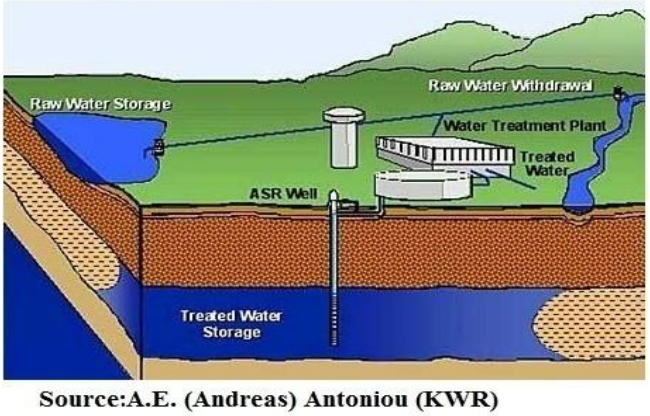
With the passage of time by the development of science and technology our understanding of hydrological system has increased which gave us number of management options but only few are sustainable and using them wisely is cost efficient and productive.

6.5.2. (ASR) Aquifer Storage and Recovery (Example from Wichita):

Aquifer Storage and recharge(ASR) (asrforum) is the storage of water in a well during the wet period and recovering that water from the well during the dry period or when ever needed.

It's a very innovative idea to deal with both flood and droughts .An excess water during the flood period is stored in an underground

(ASR) Aquifer Storage and Recovery



Source:A.E. (Andreas) Antoniou (KWR)

reservoir save the cost of on surface reservoir and environmental impacts recharging the ground water and then using the same stored water when ever needed.

a) Benefits of ASR

Department of Ecology Washington explains some of the major benefits of ASR include (Nazy, n.d.)

1. Deep underground surplus water can be stored. this not only save the cost of huge reservoirs but also related impacts including environmental, water losses, migration, land acquisition, salt intrusion and possible act of terrorism
2. The system itself is very environmentally friendly and also offers more protection from tempering
3. It also helps to restore the ground water table to meet the growing urban water demand.

b) Success and Failure:

ASR is a unique technology different from production wells and injection wells (3000ft) where the water is stored in an underground aquifer ranging 1000 to 2000 ft and ensures success in almost all the situations but lake of understanding the concept and technical aspects could lead to failure. Wells can be set in places where it's easier to capture water. The first ASR system was set at Manatee County, Florida in 1983 and now the county has started with their third phase of ASR expansion that includes four wells with the combined capacity of 10MGD (asrforum).

c) Countries Benefiting From ASR

There are so many countries that are using and getting benefit out of ASR. This populated list consists of United States, United Kingdom, Canada, Israel and South Africa. The development programs for ASR are in Netherlands, New Zealand, Kuwait, Thailand and Taiwan (asrforum).

d) Case Study of ASR in Wichita

The vision for Wichita's water resources (Government of Wichita, 2011) is reliable source of water through the year 2050 and beyond with Wichita Equus Beds Aquifer and Recovery Project. Today the mode has attracted visitors from china, Australia, Nepal, India and Bangladesh. The major source of water for the city of Wichita since 1940s is the Equus Beds Aquifer. It covers some portions of Sedgwick, Harvey, Reno and McPherson counties. The aquifer is about

900,000 acres and average withdrawal is 157,000 acre-feet annually with the major consumers including Irrigators with 55%, Municipalities with 39% and industry with 6%.Since 1950 the ground water level has been lower up to 40% because of over usage. With the lowering of water table in the aquifer salt water from Arkansas River is a major threat. If no actions were taken the chlorine concentration would have made the water unsuitable for drinking or irrigation.

The project as a whole wills benefit the whole region by

- Adding 70 billion gallons of water to the aquifer to meet the future needs in drought periods
- Restrict the salt water intrusion
- As a result of higher ground level reduced cost of power for pumping

So far during the demonstration project, successful water recharged within the aquifer is about 780 million gallons from May 1997 through January 2000 that just in accordance to what the managers had planned to achieve.

7. CONCLUSION:

Climate change is impacting the intensity and variability of Water, where too much water cause floods and too less water causing drought or water scarcity. Pakistan is one of the countries that has been a victim of Global climate change and had faced worst flood and drought events in the past and the intensity of these disasters will increase in the coming years. Today it's a matter of survival. Bad strategies and options used by the managers for flood mitigation has not only been a waste of money but had threatened the lives and economy of the country. If Pakistan wants to stand in the list of modern countries where everyone is planning to move towards water sensitive state, country managers and policymakers need to learn lessons and change their way of doing things.

Lai Nullah has been a victim of bad non reliable options used for flood mitigation by the local government. These bad options which include dredging were not only a waste of money and resources but has resulted long term damage to the area by impacting on land use and environment. The analysis of the options used in both the projects at Lai Nullah showed that the projects were unable to achieve the goal and were failure, since the holistic approach was not applied. Case study from West Virginia clearly stating, that Dredging as a long-term solution for flood mitigation has proven to be neither effective nor cost efficient. Lessons learned from the case study of Upper Mississippi river basin reveals that flood plans would be best managed in long term through the combination of structural and non structural measures applied in a reasonable manner that recognizes the risk of occupying flood prone areas. It is also clear from the study that there are no new strategies with the local government to deal with flood situation other than dredging in the next season, increasing water demand and ground water depletion, Encroachments, Garbage and waste disposal in the stream. Lai Nullah is blessed with so much of storm water and many countries are using it in different way not only to recharge their ground water, flood mitigation but also the factors of environment, social welfare and economics are equally considered. IWRM approach used in Lai Nullah case gives an understanding of problematic situation and brought new insights that helped in exposing new options such as ASR and WSUD.

8. REFERENCES:

Ali, S., 2000. Productivity Growth in Pakistan's Agriculture 1960-1996. PhD dissertation, Department of Economics, Simon Fraser University, Canada

ADB, 2006.Resettlement Planning. Project Number: 37003.Rawalpindi,Pakistan:WASA/ADB

Appendix,H,.2004.Dredging and Stream Channel Restoration, Case Study of West Virginia.P,225-P,235

Argent,R,.1995.Urban water cycle definition and description, Urban Water Lifecycle Partnership: Australian Science & Technology Council, pp. 11-26

ADB project suspension,2009. Review and Assessment Report of the Special Project Facilitator on the Rawalpindi Environmental Improvement Project. 2211/2212(SF)-PAK:Asian Development Bank

Anwar,F& Ahmad,M,.2010.Laying the Blueprint for a Model Water Utility. Rawalpindi Water and Sanitation Agency, Punjab, Pakistan. Islamabad: Water and Sanitation Program,World Bank:

Berz, G., 2001. Climate change: Effects on and possible responses by the insurance industry,Unpublished manuscript, Munich Re (gberz@munichre.com)

Bromage,J.A.R,.1924.The Construction of the Rawalpindi city Water Supply Extension Scheme. PAPER No.104.Rawalpidi.

Brown,R.R,.2008.Local Institutional Development and Organizational Change for Advancing Sustainable Urban Water Futures. Environmental Management

Beintema,M.N et al.,2007. Agricultural Research and Development in Pakistan. ASTI Country Report.Pakistan: IFPRI and PARC ;Cited in Ministry of Finance. 2006. Economic Survey of Pakistan. 2005–06.

Christensen, J.H., B. Hewitson, et al., 2007. Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Checkland,Peter B., 2000. Soft Systems Methodology: A thirty year retrospective. Systems Research and Behavioral Science, 17, 11–58

Campbell, D., 1975. Degrees of freedom and the case study. Comparative Political Studies,

8, 178-185

Chanan,A, et al,.2007. Harvesting Rainwater for Environment, Conservation & Education, Some Australian Case Studies: Faculty of Engineering, University of Technology, Sydney (UTS)

Estrela, T. et al., 2001. Sustainable water use in Europe Part 3: Extreme hydrological events: floods and droughts

Eisenreich, S.J,.2005.Climate Change and the European Water Dimension. EU Report No.21553.

Farooq,Z & Masood,Z,.2011. RDA or WASA ! Who is responsible for LAI?. 18JANUARY.Rawalpindi:White Island Blog

Fahmy,H,.2008. International Congress on Irrigation and Drainage. Plenary Report - Sustainable Integrated Water Resources Management. 13-18 October 2008, Lahore, Pakistan

Govt of S.Australia,.2009.Stormwater strategy, The future of storm water management. Australia: Government of S.Australia

Govt of Wichita,2011. Wichita Area Future Water Supply, A Model Program for Other Municipalities: Copyright 2011 City of Wichita / 455 N. Main, Wichita, KS 6720

Green,C,.2004.Flood risk management in the context of Integrated Water Resource Management. Enfield, United Kingdom: Middlesex University

Gulsecen, S. and Kubat, A,.2006. Teaching ICT to teacher candidates using PBL: A qualitative and quantitative evaluation. Educational Technology & Society, 9 (2): 96-106.

Hassing,J,.2006. Toolbox- components, functions and plans for further developments; Working with the IWRM ToolBox :Global Water Partnership

Hinds, P.S., Vogel, R.J,.1997. 'The possibilities and pitfalls of doing a secondary analysis of a qualitative data set', Qualitative Health Research, vol. 7(3): 408-24

Islam-Ul-Haq &Cheema,A.W,.2009.Adverse effects of poor waste water management practices on ground water quality in Rawalpindi and mitigation strategies. Rawalpindi: Water and Sanitation Authority Rawalpindi.

IPCC, 2007.Summary for Policymakers. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Kundzewicz, Z. W., 2002. Non-structural flood protection and sustainability. Water International 27(1): 3-13

Kundzewicz, Z.W., 2003. Flood risk and vulnerability in the changing world, International Conference towards natural flood reduction strategies Warsaw

Kazi, S. A., 1951.Climatic regions of West Pakistan. Pak. Geogr. Rev., 6,1–22

Kureshy, K. U., 1998. Geography of Pakistan. Natl. Book Serv., Lahore, Pakistan

Kronstadt,A.et al.,2010.Flooding in Pakistan: Overview and Issues for Congress Congressional Research Service7-5700 R41424

Kumar,M,.2000.Aqua Dholavira, Archaeology: A Publication of the Archaeological Institute of America, Volume 53, No. 6, November/December 2000

Khan,H&Khan,A,.2008. Natural hazards and disaster management in Pakistan. Munich Personal RePEc Archive,Pakistan.

Liu,L,.2007. United Nations Back Ground Paper on Drought, An Assessment of Asian and Pacific Progress. ESD/RIM/2007/INF. Jakarta Indonesia

Marshall, M., 2010. Frozen jet stream links Pakistan floods, Russian fires, New Sci., 2773, 6

Mir,A,. 2010. Assessment of Impact of Climate Change and extreme events on energy installations and energy supply infrastructures in Pakistan. Presentation to Joint ICTP / IAEA Workshop on Vulnerability of Energy Systems to Climate Change and Extreme Events. Italy. 19-23 April.

Newman,P,.2007.Sustainability and the Urban Water System, Case Study. Institute for Sustainability and Technology Policy, Murdoch University

Planning commission of Pakistan .2011. National Flood Reconstruction Plan; Flood Construction Unit. Jawaid Azfar Computer Centre (JACC) Planning Commission

PMPIU,2009.National Seminar on "Water Conservation, Present Situation and Future Strategy".Islamabad club Auditorium. 21 May:Project Management & Policy Implementation Unit (PMPIU) of the Ministry of Water & Power Pakistan

PTS,2010.Pakistan Lost around worth $4 billion of Water due to lack of Dams. 25 August

Available at : http://www.pakistantopstories.com/2010/08/pakistan-loses-around-4-billion-of-water-due-to-lack-of-dams/[Accessed October 16, 2011]

PWP, 2010.Pakistan Water Partnership Responds to Flood Catastrophe. Global Water Partnership Pressroom

Available at :http://www.gwp.org/en/gwp-in-action/South-Asia/News-and-Activities-GWP-South-Asia/GWP-Pakistan-Responds-to-Flood-Catastrophe/[Accessed October 09, 2011]

RWASA Water quality report, 2003.Water quality status third report , 2003 Chapter-1, page 3 , Islamabad,Pakistan.Pakistan Council of Research in Water Resources

Sarfaraz ,2007. Monsoon Dynamics its behavioral impact in Pakistan's Perspective: Pakistan Journal of Meteorology Vol. 4 Issue 7: Pakistan Meteroligical Department

Stake, R.E,.1995. The Art of Case Study Research: Perspective in Practice. London: Sage.

Szabo, V. and Strang, V.R,.1997. 'Secondary analysis of qualitative data', Advances in Nursing Science, vol. 20(2): 66-74.

Stenekes.N, et al,.2004. Sustainable water management in Australia, An institutional analysis, In Proceedings of Good Water Governance for People and Nature: Water Roles for Law, Institutions & Finance Conference, Dundee, Scotland, August 29-September 2, 2004

Schultz,B,.2007. WATER SECURITYWHAT DOES IT MEAN, WHAT MAY IT IMPLY? Discussion Draft Paper for the session on Water Security.Delft, The Netherlands:UNESCO-IHE

UNISDR, 2009. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action.Geneva, Switzerland:United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR)

WCD,2000. Tarbela Dam and related aspects of the Indus River Basin Pakistan, A WCD case study prepared as an input to the World Commission on Dams. Cape Town, Asianics Agro-Dev. International (Pvt) Ltd.

WSSD,2002. World Summit for Sustainable Development.August26-September04, Johannesburg .

WHO. 1999.Task Force on Climate and Health. Geneva WHO/SDE/99.4

Wong,T & Brown,R,.2008. Transitioning to Water Sensitive Cities;Ensuring Resilience through a new Hydro-Social Contract.11th International Conference on Urban Drainage, Edinburgh, Scotland, UK: Monash University, Victoria, Australia .

Wong,T& Ashley,R,.2006.International Working Group on Water Sensitive Urban Design, submission to the IWA/IAHR Joint Committee on Urban Drainage, March 2006

Zhanyi,G,.2008. International Congress on Irrigation and Drainage.Plenary Report- Roles of Public and Private Sector in Water Management. 13-18 October 2008, Lahore, Pakistan.

Newspaper & Internet Sources

asrforum, n.d,.Aquifer Storage and recharge official website http://www.asrforum.com/[Accessed March 16, 2011]

Ahmad.S., 2011.Government officials and landlords maximized the flood, View Point Online Issue no.79,December 02.

Available at: http://www.viewpointonline.net/the-unbridled-invitations-to-floods-in-pakistan.html [Accessed Dec 02, 2011]

Balochistan Times,2009.Rs.91 million allocated for cleaning Nullah Lai. 21 May.Rawalpindi:Asia Pulse Pty Ltd

Available at : http://www.thefreelibrary.com/Rs.91+million+allocated+for+cleaning+Nullah+Lai.-a0200429495[Accessed July 16, 2011]

Daily Times,2011. Citizens urged not to throw garbage in nullahs, drains. 29June.Rawalpindi.Daily Times Newspaper

Available at : http://www.dailytimes.com.pk/default.asp?page=2011\06\29\story_29-6-2011_pg11_7[Accessed May 16, 2011]

Dunya News 2011 .Flood Warning Issued after water level rise in Nullah Lai. 16 July, [Internet]

Available at : http://dunyanews.tv/index.php?key=Q2F0SUQ9MiNOaWQ9MzA2NzI=&utm_source=twitterfeed&utm_medium=twitter[Accessed Aug16, 2011]

Dredgingtoday,2010.Officials Approve Rs.5Million for Nullah Lai Dredging.22 June.Rawalpindi: Dredgingtoday, [Internet]

Available at : http://www.dredgingtoday.com/2010/06/22/pakistan-officials-approve-rs5-million-for-nullah-leh-dredging/[Accessed Sep 22, 2011]

Daily Times,2011.No flood danger during monsoon. 27June.Daily Times Pakistan, [Internet] Available at : http://www.dailytimes.com.pk/default.asp?page=2011%5C06%5C27%5Cstory_27-6-2011_pg11_6[Accessed Feb15, 2011]

dredgingtoday,2010.Residents urge for dredging of Nullah Leh Rawalpindi. 16 April: Dredgingtoday, [Internet]

Available at : http://www.dredgingtoday.com/2010/04/16/residents-urge-for-dredging-of-nullah-leh-pakistan/[Accessed Aug 16, 2011]

Frontier Star,2010. Illegal water connections in full swing in Cantonment Board Rawalpindi.23 july, COPYRIGHT 2011 Asia Pulse Pty Ltd

Available at : http://www.thefreelibrary.com/Illegal+water+connections+in+full+swing+in+Cantonment+Board…-a0262422573 [Accessed Aug 19, 2011]

Government of Pakistan Ministry of Environment .2011. National Climate Change Policy. Available at http://www.lead.org.pk/attachments/env_policy/climate_change_policy.pdf [accessed Apr 18, 2011]

GWP, 2000.Integrated Water Resources Management. GWP Technical Advisory Committee, Background Paper 4. Stockholm: Global Water Partnership Secretariat

Available at : http://www.gwptoolbox.org/images/stories/gwplibrary/background/tac_4_english.pdf[Accessed Mar 21, 2011]

GWP,2010,Water Financing contributions to African and Med processes. Monthly report for March.Global Water Partnership Press room.

Available at : http://www.gwpsudamerica.org/docs/publicacoes/doc_220_sp.pdf[Accessed Feb 16, 2011]

Hassan,M,.2011.Torrential rain claims nine lives in Pakistan.Rawalpindi. 26 Jul. The Newstribe

Available at : http://www.thenewstribe.com/2011/07/26/torrential-rain-claims-nine-lives-in-pakistan/#.TpR0MZuybMY[Accessed Jun 16, 2011]

IEG World Bank, 2010. Response to Pakistan's Floods: Evaluative Lessons and Opportunity. Available at: http://siteresources.worldbank.org/EXTDIRGEN/Resources/ieg_pakistan_note.pdf

IFM, 2000. Making Integrated Flood Management as a part of development agenda. Available at http://www.apfm.info/pdf/iwrm_floods.pdf [Accessed Mar 14, 2011]

IUCN. (n.d). Causes of Floods in Pakistan.

Available at: http://waterinfo.net.pk/cms/?q=fip [Accessed Aug15, 2011]

Inception Report,2007. Project for Strengthening of Flood Risk Management in Lai Nullah Basin.Japan International Cooperation Agency.

Available at : http://www.pakmet.com.pk/nl/inception%20report.pdf [Accessed Feb 16, 2011]

Iqbal,K,.2011.Are our flood warning systems in working condition?.The News. Rawalpindi.03July.

Available at : http://www.thenews.com.pk/TodaysPrintDetail.aspx?ID=55693&Cat=6&dt=7/3/2011[Accessed Mar 26, 2011]

JICA Press Release, 2011.Japan funds UNESCO for strengthening flood warning system in Pakistan.12July.Islamabad,Pakistan

Available at : http://www.jica.go.jp/pakistan/english/office/topics/press110712.html[Accessed Jun 16, 2011]

Javaid,Z,.2010. Allocation for water sector down by 39.85%,Daily Times Pakistan,Islamabad,06 June.

Available at : http://www.dailytimes.com.pk/default.asp?page=2010/06/06/story_6-6-2010_pg5_5 [Accessed Jun 13, 2011]

Khattak,I,.2009. ADB stops Rawalpindi environment project funding.10 May.Dawn Newspaper.

Available at : http://archives.dawn.com/archives/120652[Accessed July19, 2011]

Khattak,I,.2011.Pindi to have solid waste converter technology. 08January.Rawalpindi.Dawn News Pakistan

Available at : http://www.dawn.com/2011/01/09/pindi-to-have-solid-waste-converter-technology.html[Accessed Aug 16, 2011]

Kamal,A,.2004.Lai Nullah Basin Flood Problem. Pakistan:WMO/GWP

Available at :http://www.apfm.info/pdf/case_studies/cs_pakistan_nullah.pdf[Accessed October 16, 2011]

Lovelace,T,J & Strauser,N,C,.1993.Protecting Society from Flood Damage, A case study from Upper Mississippi River Flood. Mississippi,Canada: U.S. Army Corps of Engineers

Available at : http://mvs-wc.mvs.usace.army.mil/papers/93flood/93flood.html[Accessed October 14, 2011]

Mulk,S & Ahmad,I.,2010. Task force on climate change.Final Report.Planning Commission Government of Pakistan.

Available at : http://www.scribd.com/doc/56542295/Final-Report-Planning-Com-Iss-Ions-Task-Force-on-Climate-Change-Government-of-Pakistan[Accessed Jan 26, 2011]

Mustafa.D,.2010. Hydropolitics in Pakistan's Indus Basin.Special Report 261.Washington: United States Institute of Peace All rights reserved

Available at: http://www.usip.org/files/resources/SR261%20-%20Hydropolitics_in_Pakistan's%20_Indus_Basin.pdf[Accessed July 16, 2011]

New York Times, 2010. Pakistan Floods. Available at: http://topics.nytimes.com/top/reference/timestopics/subjects/f/floods/2010_pakistan_floods/index.html?scp=1-spot&sq=Pakistan%20floods&st=cse [Accessed Sep 16, 2011]

Nazy,D,. n.d. Aquifer Storage and Recovery. Official State Government Website. Department of Ecology Washington

Available at : http://www.ecy.wa.gov/programs/wr/asr/asr-home.html[Accessed Mar 16, 2011]

Oxley.M,. 2011; Field note from Pakistan floods: Preventing future flood disasters.JAMBA Journal of Disaster Risk Studies, Vol. 3, No.2

Available at : http://acds.co.za/uploads/jamba/vol3no2/oxley_3_2.pdf[Accessed Apr 22, 2011]

Pakistan Daily,2010. Pakistan Floods Caused Due to Water Release by India.Pakistan Daily, 05August

Available at: http://www.daily.pk/pakistan-floods-caused-due-to-water-release-by-india-19621/[Accessed Feb 13, 2011]

Pamirtimes,2010. Integrated Water Resources Management to mitigate floods and droughts in Pakistan.Islamabad ,Pakistan.26 Feburary.

Available at :http://pamirtimes.net/2011/02/26/integrated-water-resources-management-to-mitigate-floods-and-droughts-in-pakistan-unesco/[Accessed Aug 03, 2011]

Rashid.A.,2004.Impact of EL-NINO on Summer Monsoon rainfall of Pakistan. Volume 1 Issue 2. Pakistan Journal of Metrology

http://www.pakmet.com.pk/rnd/rnd_files/vol1_issue2/3.%20MPACT%20OF%20EL_NINO%20ON%20SUMMER%20MONSOON%20RAINFALL%20OF%20PAKISTAN.pdf[Accessed May 09, 2011]

REIP, 2004.Summary of Environmental Impact Assessment. Il-A Final Report (TA 4098-PAK).Lahore: NESPAK (International).

Available at : http://www.adb.org/documents/produced-under-ta/37003/37003-01-pak-dpta.pdf[Accessed May 16, 2011]

Quo Report Rawalpindi, 2006.Urban Water Supply and Sewerage Reform Strategy.World Bank, Government of Punjab:Fichtner GmbH & Co. K

Available at : http://www.urbanunit.gov.pk/pubpublic/pubcomp/50.pdf[Accessed Apr 26, 2011

Sabzwari,2006. Country Water Action: Pakistan Project Brings Hope for Clean-up of Rawalpindi's "Shame".Rawalpindi.Asian Development Bank Press

Available at : http://www.adb.org/water/actions/PAK/Rawalpindi-hope.asp[Accessed Jan 12, 2011]

Shazia, 2010.Monsoon Rains & Flood in Pakistan. Forumpakistan, [Internet]

Available at :http://www.forumpakistan.com/monsoon-rains-and-flood-in-pakistan-t57016.html[Accessed October 16, 2011]

The Nation, 2010.Land purchased for extension of Nullah Lai again occupied. November 1.The Nation Daily.

Available at : http://www.nation.com.pk/pakistan-news-newspaper-daily-english-online/Islamabad/01-Nov-2010/Land-purchase-for-extension-of-Nullah-Lai-again-occupied[Accessed Feb 16, 2011]

The News 2011. Nulla Lai in high Flood.Rawalpindi.25 July.The News Daily Pakistan

Available at : http://www.thenews.com.pk/NewsDetail.aspx?ID=19367&title=Nulla-Lai-in-high-flood[Accessed Mar 01, 2011]

UNCED,1992.Agenda 21.United Nations Department of Economic and Social Affairs.

Available at : http://www.un.org/jsummit/html/basic_info/agenda21.html[Accessed July 16, 2011]

UN, 1992. Article 1, United Nation Framework Convention on Climate Change. FCCC/INFORMAL/84 GE.05-62220 (E) 200705

Available at : http://unfccc.int/resource/docs/convkp/conveng.pdf [Accessed Aug 23, 2011]

WASA,2009.Report on Project Dredging of Lai Nullah.Rawalpindi Water and Sanitation Authority Available at : http://wasa.rda.gov.pk/downloads/Dreding_june_2009.pdf[Accessed Aug 17, 2011]

Waraich,A,.2011.Dunya Tv.Chamera Man Gardezi,S,.29June.Lai Nullah Rawalpindi,Pakistan: http://www.dunyanews.tv

Available at : http://www.youtube.com/watch?v=5Y8QW0hAT4A[Accessed May 06, 2011]